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Climate Change

BUILDING CLIMATE SMART FARMERS (A Guidebook for Doubling Income of Farmers in Arena of Climate Change)

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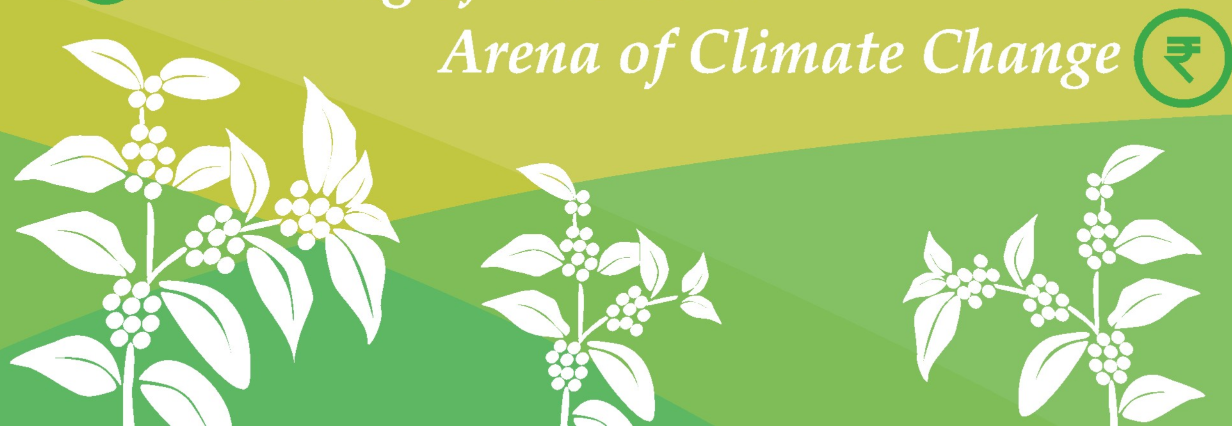
Building Climate Smart Farmers

Doubling of Income in Arena of Climate Change



ABOUT THE AUTHORS...

DR. KIRIT SHELAT

Dr. Kirit Nanubhai Shelat (born 1946) was a public administrator for the government of Gujarat, India. He is currently associated with NGOs and Trusts.

Dr. Kirit Nanubhai Shelat is Ph.D in Public Administration. He recently retired from the Indian Administrative Service. During his career of 40 years, he started from the grass-root level. He has his hand in the formulation and implementation of policies for Agricultural, rural and Industrial development for Government of Gujarat, India. He has worked as Head of various Government Departments and Public Undertakings.

He has designed and implemented large-scale projects for poor families, farmers, and micro entrepreneurs and remote rural areas. He has made a significant contribution in the development process of Gujarat, India. He developed guidelines for Micro-level planning with focus on individual poor family and village development plan. He was responsible for "Cluster development approach' for small industries and "Step up project for rural micro level Entrepreneurs. He developed micro level production plan module for individual farmer and has his hand in restructuring the Gujarat agriculture sector. He introduced new extension approach of meeting with farmers at their door step prior to monsoon by team led by agriculture scientist. He introduced scientific agriculture based on soil health and moisture analysis and providing a soil health card to every farmers of Gujarat. This effort went in a long way in developing sustainable agriculture in Gujarat will growth rate of 11% per annum in the last decade. After his retirement as Principal Secretary – Agriculture and Cooperation Department, Government of Gujarat, he is associated with multi-dimensional rural and agricultural development programmes.

He is also the Founder Members of International School for Public Leadership and Executive Chairman of National Council for Climate Change Sustainable Development and Public Leadership (NCCSD) and Chairman of the Sub Group - "Enhancing Preparedness for Climate Change" set up Planning Commission, India for the 12th Five Year Plan.

He is author of number of books related Rural and Agricultural Development and Mitigation of Global Warming and Public Leadership.

DR. ODEMARI MBUYA

Dr. Odemari Mbuya is a professor of Agricultural Sciences at Florida Agricultural and Mechanical University (FAMU) and a Courtesy Professor of Agronomy at the Institute of Food and Agricultural Sciences, University of Florida.Dr. Mbuya holds a B.Sc. degree in Crop Science from Sokoine University of Agriculture (Tanzania)and M.Sc. and Ph.D. degrees from the University of Florida (USA).Dr. Mbuya has worked in Tanzania as an Agricultural Research Scientist in Tanzania, at CIAT (Centro International Agriculture Tropical) in Colombia as a visiting researcher, and as a consultant representing the United States Department of Agriculture in SouthAfrica and India.In his tenure at FAMU, Dr. Mbuya has served in numerous national and international committees representing water resources, climate change, agricultural production and biofuels. He is currently the Director of the Center of Water Resources, Director of the Florida Climate Institute at FAMU (a consortium of 10 public universities in Florida, USA), and the Program Leader of Agronomy, Soil and Water Sciences.Dr. Mbuya leads the faculty effort in integrating all concepts of sustainability in innovative research, teaching and outreach at FAMU and beyond. Among his many duties, Dr. Mbuya teaches several graduate and undergraduate courses, including Statistical Research Methods/Biostatistics, Plant and Soil Sciences. His research interests focus on phytoremediation, water resources, watershed processes and computer simulation modeling.

BUILDING CLIMATE SMART FARMERS

A GUIDEBOOK
for
Doubling Income of Farmers in Arena of Climate Change

EDITED BY

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JOINTLY PUBLISHED BY

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Doubling Income of Farmers in Arena of Climate Change

Editor
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Editor would be happy to receive Comments and sharing of Experiences from readers

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सत्यमेव जयते

प्रधान मंत्री

Prime Minister

MESSAGE

I am delighted to learn that the National Council for Climate Change Sustainable Development and Public Leadership is coming out with a guidebook "Doubling of Income of Farmers in Arena of Climate Change".

I congratulate the authors Dr. Kirit Shelat and Prof. Odemari Mbuya on their effort and also commend them for throwing light on an important subject that impacts the future of our nation as well as of humankind.

Farmers are our 'Annadaatas' - the people who put in their sweat and toil, just to feed billions. It is our duty to ensure their welfare, from their income to their ease of living. We are working towards making the lives of farmers better at every stage of the farming cycle, from seeds to insurance, from machines to markets.

One of the most important factors in the farming cycle is climate. Changes in climate patterns will profoundly impact agriculture, and in turn, all of us. Hence, enlightening perspectives that study these phenomena are crucial for our planet.

Once again, I congratulate the authors as well as the National Council for Climate Change Sustainable Development and Public Leadership for undertaking this important effort. I am sure your work will go a long way in building a better future for our farmers.

I wish you all the best in your endeavours.

(Narendra Modi)

New Delhi 11
January, 2018

Dr. Kirit N. Shelat
Executive Chairman
NCCSD
Patel Block, Rajdeep Electronic's Compound
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Ahmedabad- 380014

FOREWORD

Climate Change poses the greatest challenge to sustainable agriculture and food security. I am therefore happy that a comprehensive guidebook for farmers has been prepared by Dr. Kirit N. Shelat and Dr.Odemari Mbuya. As pointed out in this book, there is need for synergy between technology and public policy for overcoming successfully the adverse impact of changes in temperature, precipitation and sea level on crop and animal husbandry, fisheries and forestry.

There is a growing knowledge about methods of promoting Climate Smart Agriculture and this book provides useful insights into the various steps. We should take to insulate farming and building climate smart farmers for the impact of climate change which also simultaneously increase their income. Dr. Kirit Shelat has rightly pointed out the need for public leadership in this area. Public participation and public leadership are both vital for imparting climate resilience in our economic activities.

I also agree with Dr. Odemari Mbuya of Florida Agriculture & Mechanical University that we need to reduce GHG emission by agriculture sector as a whole.

I welcome this global cooperation. The agricultural scientists from Florida Agricultural & Mechanical University – Florida U.S.A. have made valuable contribution led by Dr. Mbuya under international cooperation programme led by Dr. Harriett Paul. These efforts always remind us that world is small and there is fraternity which supports one another.

The focus on farmer is need of time for achieving food security and food to hungry millions and urbanite. I therefore, like the concept of Building Climate Smart Farmers as climate adversities are on increase – the brunt of its adverse effect is on them. The world community therefore needs a strong farmer who can overcome barriers and simultaneously increase his income. In fact that is why our Hon'ble Prime Minister Shri Narendra Modi has given a call to Double Income of Farmers in five years.

The Non-formal Education Centre at Shri Vivekanand Research & Training Institute – Mandvi – Gujarat, will become a landmark of international cooperation and exchange to pave way for building farmers. I congratulate Shri Ashwinbhai Shroff to take up the lead for the way forward.

I congratulate NCCSD for its continuing efforts to develop Climate Smart Farmers and make available the expertise gained to farmers not only of India – but of all developing countries.

I am sure this guidebook will be useful not only to Farmers – but also Extension Team, Students and all those who have interest in agriculture.

Mandvi, Kuchchh
30 December 2017

Kantisen Shroff

PREFACE

Greetings from National Council for Climate Change, Sustainable Development and Public Leadership (NCCSD). This is an endeavour to bring out a comprehensive guidebook on impact of climate change and how to use about Climate Smart Agriculture by farmers on their own to sustain and increase their income based on our own and international experiences. First of all, we take this opportunity to congratulate the Director General, FAO for bringing focus on Climate Smart Agriculture and producing a comprehensive resource book on that and followed up creating GACSA (Global Alliance on Climate Smart Agriculture) for its global application and which is now doing very good work in this regard. We have adapted parts of this book for Indian conditions.

In fact, NCCSD was set up with the objective of promoting sustainable livelihood, with the involvement of leadership, for farmers in the arena of climate change. It is continuously holding seminars, think tank meetings, national and international conferences and series of interactions with farmers and holding capacity building programmes for farmers, local level leaders, extension team, women farmers and rural youth to develop a framework which can be used by farmers. This book is the outcome of these efforts. One major realization has been that Indian farmers have immense capacity to adapt and accept the challenges of climate change. They are open to new ideas – but there is no uniform spread or use by all. India's development administration, agricultural scientists and civil society members have worked hand in hand with farmers to face adverse situation that existed at the time of independence. The country's economy has been transformed and has been able to develop sustainable agriculture with increased growth rate. This has enabled India to meet food scarcity problem. We are aware that the country depended on imports of wheat in initial years and we had "Ration Shops" as part of Public

Distribution System and today we are the exporter of wheat and many other commodities.

Food systems have evolved over time to support human civilization. Population growth is the single largest challenge to meet the demand of future food needs. The world population is projected to be 9.6 billion people by 2050. To feed all these people majority of which will be increased urbanites by advancing rural development, reducing greenhouse gas (GHG) emissions, and protecting valuable ecosystems is one of the greatest challenges of our time. It is estimated that crop production have to double to meet global food demand. In order to produce sufficient food to feed the ever increasing hungry millions, we will depend more on science and technology than before. While applications of science and technology within the food system have allowed production of foods in adequate quantities to meet the needs of society as it has evolved, national food policy is equally important. India has taken series of initiatives in this regard and has been alert on this front to remove the imbalance of food production and population growth. Government policy is focused on agricultural production and food supply through price subsidies, trade policy, government food procurement and investments in agricultural research, extension and outreach. In fact the Prime Minister Shri Modi has given call to double the income of farmers in arena of climate change and this book is in response to that call for agriculture administration – farmers and all stakeholders.

We cannot just produce more food in the same way as today; we must also reduce food's environmental impact. Agriculture contributes nearly 25% of global greenhouse gas emissions, uses 37% of landmass (excluding Antarctica), and accounts for 70% of all freshwater withdrawn from rivers, lakes, and aquifers (for irrigation). Agriculture production largely depends on climate among other factors. Change in global or regional climate patterns (Climate Change) is a phenomenon that is evident throughout the world. Farmers must adapt to climate change by practicing Climate Smart Agriculture (CSA). CSA is an approach for transforming and reorienting agricultural development under the new realities of climate change. CSA is agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces/removes

GHGs (mitigation) where possible, and enhances achievement of national food security and development goals. The principal goal of CSA is food security (and development); while productivity, adaptation, and mitigation are identified as the three interlinked pillars necessary for achieving this goal. But more precisely the book recognizes that the agriculture through its photosynthesis process absorbs CO2 and is important nature's tool for mitigation and therefore its use by its expansion in wasteland and degraded areas will enhance food production and provide livelihood apart from meeting challenge of food security which is outlined in famous Paris Agreement. International community and national government need to prioritize agriculture and mainstream it with focus on small holder. The book especially suggests ways how small holders with little modification of practices can not only sustain crops but also enhance its productivity and get higher value from market. How some of them have achieved this and that the others can not be left behind.

The Indian farmer is an integral part of agricultural development and food security at local, national and global level. This book will provide simplified agricultural scientific tools that will help to engage our farmers to increase productivity and profits while protecting the environment and natural resources for future generations.

This guidebook is fifth in its series. The first three are in Gujarati, one in Hindi and now this one is in English. The fourth Gujarati updated version is on its way. NCCSD is updating this at regular interval to incorporate impact of continuing climatic change and possible solutions.

The most important contribution which has added value is contribution by Florida Agricultural and Mechanical University (FAMU) team of scientists who visited our farmers and trained them. They are taking our farmers further on way to match and become competent like their advanced counterparts of developed world. They not only visited but helped to develop learning material. This started with NCCSD signing a Memorandum of Understanding (MoU) with FAMU in 2014 and followed by visit of Dr. Odemari Mbuya and Dr. Mehboob Sheikh. Ms. (Dr.) Harriett Paul took initiative to get support from USAID and U.S. government to send a team of scientists. We had convergence of efforts with the government of Gujarat. Dr. Sanjay Prasad (Principal

Secretary), took active interest and State Agriculture Department, Universities and ATMA joined hands. The noteworthy is creation of Non-formal Education Centre at Shri Vivekanand Research and Training Institute (VRTI) at Mandvi, supported under CSR of Excel Group of Industries, led by Shri Ashwin Shroff who is also Chairman of VRTI and fully involved in this endeavour.

The guidebook is devised in way to make farmer understand what is climate change, how it affects his productivity – crops – animals – fisheries. It contains suggestions based on scientific research by numerous Indian and U.S Scientists and of cource by some of successful farmers. It outlines the adaptation needs – which a farmer need to take with illustrative cases of success to understand that this is feasible. It thereafter shows how to enhance his income despite adversities. It provides him series of alternative choices and finally takes him to follow modern management practices - as he is an individual producer – an entrepreneur and must keep himself on part with new developments of managing his costs, getting better value of his crops and knowing where he looses and how to come out from it by adopting good agricultural practices.

The book is combination of validated research and experiences of agriculture scientists, civil society members, farmers, government departments and of course it is not a final word on this subject. It is meant to be used keeping in view local field level situation & status of farmers.

We are sure this will be useful to all stakeholders.

We are open to receive suggestions for its improvement – sharing of new successful practices – as this needs continuous updating in changing competition – scene and climate adversities.

Ahmedabad
6th January, 2018

Dr. Kirit N. Shelat
Dr. Odemari Mbuya

ACKNOWLEDGEMENT

At the outset, we would like to express our sincere gratitude to our beloved Veteran NGO - Shri Kantisen Shroff for giving us encouragement and support by writing the 'Foreword'. His efforts have paved the way for promoting sustainable agriculture in our country.

We appreciate for the continuous encouragement by Prof. M.S. Swaminathan – the man behind 'Green Revolution' as well Dr.Y.S. Rajan. We also thank to NCCSD team members, Dr. Mayur Vyas, Dr. R. H. Patel, Dr. I. R. Rathod, Dr.Ramanbhai Patel, Shri Malay Joshi, Shri Mavjibhai, Ms. Nisha Shah and Nitin Jaimini who all have worked on different subjects. Our thanks to Vice Chancellors - Dr. A. R. Pathak, Dr. N. C. Patel, Dr. C. J. Dangaria and Dr. Ashok Patel and their research team who have provided valuable inputs and that has strengthened the overall perspective on Climate Smart Agriculture. We also thank to, Dr. Arun Patel, Dr. C.M.Patel, Dr. Parekhia, Shri J.S. Gosalia and Shri Satish Chhaya for their valuable inputs.

We also thank to Shri Abhay Kothari and Shri Kathan Kothari for putting effort to build up layout and designing of this book.

Ms. Nisha Shah has edited the entire book assisted by Shri Mohandas Kallingal.

We also thank to - Dr. Vaghasiya and Dr Modi of State Agriculture Deptt., who have taken initiative in sending farmers from all districts of Gujarat in capacity building programme held by NCCSD where the learning material was developed and was tested. Dr.Sanjay Prasad – I.A.S., Principal Secretary – Agricultural Department (Gujarat), who supported this initiative. We acknowledge our sincere thanks to Mr. Michael Deal, President and CEO of Volunteers for Economic Growth Alliance (VEGA). And the USAID which sponsored U. S. Group of Scientists from Florida Agricultural and Mechanical

University, who have come all the way from U.S. and assisted to develop a training module and training methods for our farmers and trainers. The team includes - Dr. Verian D. Thomas, Mr. Trevor Hylton , Dr. Amita Jain, Dr. O.S. Mbuya, Ms. Velma Gwishiri, Dr. Kamal Hyder, Les Harrison, Jorge Luis Montezuma, Dr.Mehboob B. Shaikh-, Dr. Gilbert Queely, Mr. Chester Bunker, Mr.Glyen Holmes and Dr. Nathan Bailey. Their contribution is part of this guidebook.

Our special thanks to Dr.Odemari Mbuya, the Professor who initiated this cooperative work and he is also the editor of this book. And Dr.Harriett Paul who brought this transfer of technology. She is the person to make “the Joint International Corporation initiative” happen.

Shri Parshottam Rupala, Hon’ble Minister of Agriculture (State), Government of India, has always been acted as a source of motivation and inspiration. He has taken forward many ideas in the policy and programme framework.

Also our thanks to the President of NCCSD - Justice B P Singh – who found time for participating inter-action and think tank meets in which all ideas related to making Climate Smart Farmers have been deliberated.

Shri Bhupendrasinhji Chudasama – Hon’ble Minister – Gujarat Govt. Whatever portfolio he looks after – we have treated him as our own and as ‘Agriculture Minister’.

We sincerely thank to Shri Shreyasbhai Pandya of Sahitya Mudranalaya, Ahmedabad who is readily extended his support in all our guide books including this and sponsoring them.

We are grateful to Param Pujya Pramukh Swamijee Maharaj who inspired all of us with this work.

We are sure that this book will be of interest to all those who have anything to do with agriculture and will be used by students, scientists, practitioners and farmers for developing sustainable agriculture and livelihood.

DR. KIRIT N SHELAT

CONTENT

BACKGROUND

SUSTAINABLE DEVELOPMENT AND AGRICULTURE

Sustainable Development is a pattern of use of natural resource that aim to meet human need while protecting the environment and simultaneously to ensure the need for resources can be met not only in the present, but also in the indefinite future.

The word "Sustainable Development" has well-known implications. It is a long-term activity which involves the use of natural resources. It implies economic growth with socio-economic content. It means to provide enough of what one needs in order to live or exist and implies its gradual growth in size, quantity and quality without diminution.

It envisages gradual growth in the income of people through development of wealth of an area, of a society or for that matter of the country. It endeavours to provide better quality of life to all participants, especially to poor families and remote areas. Empowerment of the poor is the key to socio-political stability. A huge divide between the rich and the poor creates political turmoil and instability in the country. Many a times, it results in the emergence of local radical and provocative groups.

The programme for Sustainable Development varies across families, regions and countries. The development aspirations of an area and the status of the poor within the community are the principal factors that determine the components of such a programme. The process involves social, economic and environmental initiatives as a part of 'developmental programmes' initiated by the government. In a well established democracy, the civil society and the individual exert equal influence.

Sustainable Development: Nature's Forces

The sustainable development is centered on nature's principles. Nature has five important forces – Sky (atmosphere), Sun, Earth, Water and Vegetation. These forces are inter-dependent and maintain equilibrium in nature. They are also responsible for different seasons round the year – including weather cycles and climate. Appropriate use of these forces of nature generate basic resources for livelihood is important, which in turn helps to sustain the habitat and promote sustainable development.

Improper use and reckless exploitation of these resources disturb the balance of nature and affect sustainable development. For example, overdrawing of underground water leads to salinity ingress and advancement of desert while excessive use of fossil fuel leads to excess of gases in the atmosphere disturbing the heat balances. Inequitable use of resources leads to social turmoil and political instability.

How Nature Operates its System

It is well-known that the water vapour mobilized by sun's heat generates clouds. They are moved by winds in the sky and influence rain on earth – land. Due to moisture in land, the seeds germinate into plants, which in turn grow through the process of Photosynthesis.

Photosynthesis is a process by which green plants use sunlight to make their food. They use sunlight along with carbon dioxide and water to create simple sugar or glucose. Plants absorb CO2 from the atmosphere and release oxygen. Plants produce millions of new glucose molecules per second. They use these to build leaves, flowers and fruits and seeds to convert glucose into cellulose – the structural material in their cell walls. Most plants produce more glucose than they can use. Hence, they store it in the form of starch and other carbohydrates in roots, stem and leaves.

Nutrients are also transferred by plants into the soil, which increases its fertility. This is a part of the process of carbon assimilation by plants. The ancient by-products of photosynthesis are fossil fuels such as natural gas, coal and petroleum essential for the energy needs of human. Human beings and other animals too depend on glucose as an energy source, but they are not capable of producing it on their own. They are dependent on plants for glucose. Thus, virtually all lives on earth, directly or indirectly, depend on photosynthesis – the process of interaction between the five forces of nature.

Whenever nature's balance or equilibrium of its forces is disturbed, the weather cycle is adversely affected, resulting in climate change. The normal cycle of atmosphere is affected and this includes changes in weather, untimely or excess or no rain, sea level changes etc. This increases the vulnerability of our systems including agriculture to impacts of other natural calamities like earthquake or tsunami so on so and forth. In present times, this is called 'Global Warming' due to 'Greenhouse Effect'. Climate change often enhances natural calamities and has a direct impact on sustainable development. Further global warming is international phenomena but its impact is at local level-villages and farm land get affected and most vulnerable is farmers whose only source of livelihood –land-looses productivity.

CLIMATE SMART AGRICULTURE

FAO – The Food and Agriculture Organisation of world has initiated this concept. It has brought out a very rich resource book – which is all comprehensive. We have adopted some ideas – as they are and some with modification.

Why is Climate Smart Agriculture (CSA) needed?

- As per FAO estimate, by the year 2050 world population will increase by one –third and food required for food security by 60 %.
- Already cumulative impact of climate change since last decade has effect on productivity. Agriculture has become a high risk profession- farmers increasingly prefer to migrate. In India as per National Sample Survey Organization 2005 estimate 60% farmers like to leave farming.
- This has direct impact on socio-economic process. Already countries after countries are facing social turmoil with growing local terrorism and riots for food. In India this is reflected by expansion of Naxalite and MAOs activities in various states. A Movement that encourages young individuals to crimes of extortion and dacoity which has spread over 1/3rd of its total district in which they are present.
- But with available knowledge and experience, it is possible to make agriculture a sustainable livelihood means – but this will require intensive efforts at ground level – local level where agriculture exists and it has to be made climate smart.
- What CSA means:
    - It contributes to achievement of sustainable development goals
    - It integrates – social, economical and environmental development to meet challenge of providing sustainable (a) livelihood to farmers (b) food security to hungry millions, and (c) eradication of poverty.

- It is composed of four pillars:
    - Sustainably increasing agriculture productivity and income
    - Adapting and building resilience to climate change
    - Reducing and / or removing green house gas emission wherever possible
    - It uses agriculture as a major tool for mitigation of GHG – CO_2 by laying emphasis on its unique capacity to absorb CO_2 and release Oxygen through photosynthesis process. It envisages to achieve this through increased cropping, by reducing rain fed areas through integrated water and river basin management and expansion of agriculture on wasteland, wetland, degraded fallow areas and introducing urban agriculture

Source: Adapted Page IX - Climate Smart Agriculture Source Book

It is an approach for addressing the development efforts towards the technical, policy and investment condition related issues to achieve sustainable agricultural development for food security under climate change along with eradication of poverty. But its focus is to act at local level where there is already impact of climate.

There are five important reasons why we need to act together at local level:

- Climate change has already adverse impact but there are available solutions – what is needed is to translate them at village level.
- There are already existing programmes – plans – missions but they need to happen at bottom level and hence despite their existence – we need to start for CSA at bottom level
- Farmers are intelligent and shrewd – know what are their problems. Majority of farmers in India today are literate and capable of accepting new ideas and practices – so is the local level (taluka level) development administration – but they have to be prepared to develop their own production plan and we need to have confidence in them. They are capable of implementing CSA.
- For environmental concern – in the context of global warming –with increasing emission of GHG and non-willingness of lead players to provide curbs – agriculture offers a way to mitigation. Through its unique photosynthesis process, agriculture absorbs CO2 from atmosphere and releases Oxygen. There is no known technology which can do this. With

increased productivity, increase in area under agriculture and multiple cropping, world can reduce CO2. This can simultaneously provide sustainable livelihood and food security to hungry millions.

- Technologies are available, knowledge exists, plans are prepared - from top to middle level while vacuum at the bottom still remains unaddressed. Only chosen few are benefited while the majority are left out of development process in spite of claiming "all inclusive" approach. This is an identical trend across the entire developing world. Gaps exist in same village with same land and water resources – between one farmer and another farmer. The progressive one makes profit – the average one fails – and some commits suicide or others migrate to urban centres – rest drag on. But at the end result overall productivity and income to farmers suffer.

Sustainable Livelihood

A **livelihood** is **sustainable** when it can cope with and recover from the stresses & shocks and maintain or enhance its capabilities and assets both now and in the future without undermining the natural resource base (Chambers & Conway).

Household livelihood security. Household livelihood security is defined as adequate and sustainable access to income and resources to meet basic needs (Frankenberger, 1996).

The Sustainable Livelihoods Approach (SLA) is a method of analysing and changing the lives of people experiencing poverty and disadvantage. It is a participatory approach based on the recognition that all people have abilities and assets that can developed to help them improve their lives.

For individual farmer sustainable livelihood means…….

Provide enough to all to live or exist,

It should not become less and

There is gradual increase in income for better quality of life.

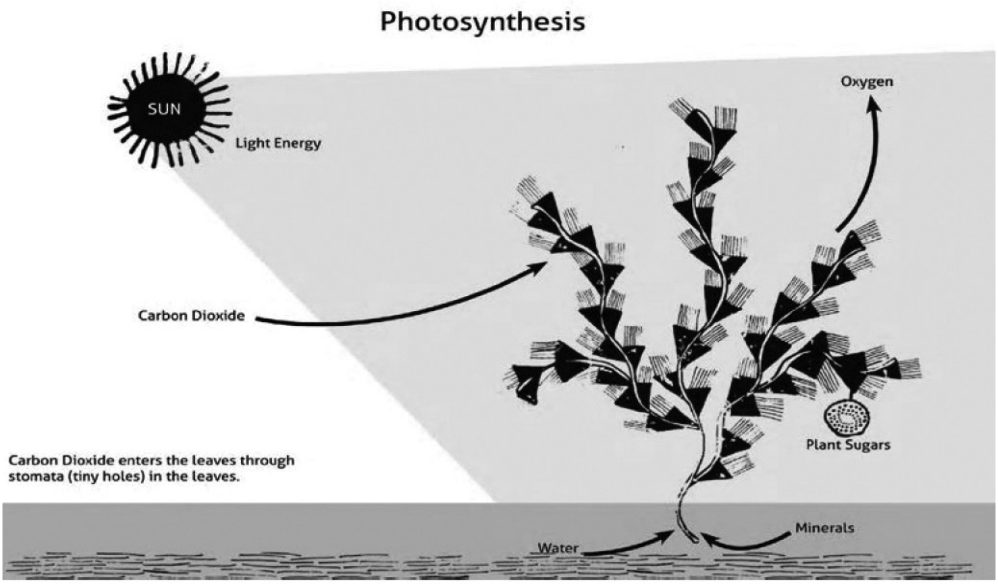
Climate Smart and Sustainable Agriculture (CSA) is a means to provide this to farmers

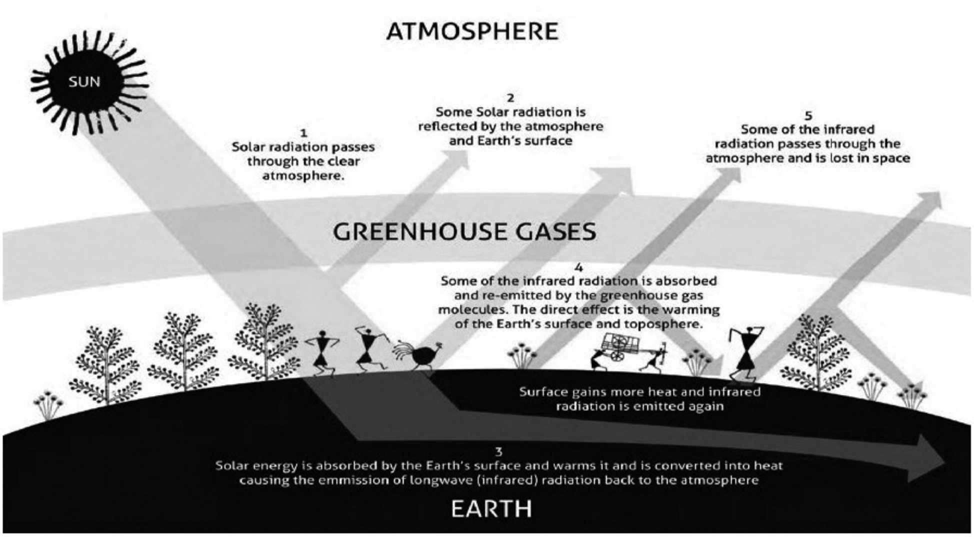
CSA endures to ensure that despite change in climate and its adverse impact on crops/animals, income to farmers should not decrease. It provides opportunities to have multiple sources of income from agriculture and animal husbandry - milch cattle and poultry, fisheries, when one fails, other supports.

It provides opportunity to young members of family to acquire multiple skills, support for setting up micro-enterprise locally, based on demand and supply situation. It provides safety net at the time of natural calamities – by way of insurance – for crops & animal husbandry along with employment in community projects.

Climate smart agriculture involves :

- Crop pattern based on soil health & moisture analysis to support crops which can be sustained.
- Agro – advisory
    a) On predicted weather pattern long term, medium term and week to week basis given by Meteorology Department – this prior to kharif and rabi season
    b) After unexpected weather that changes have occurred for corrective action to prevent crop loss and livestock management.
- Crop production that contributes to food security by addressing current and projected climate change impacts through adaption and mitigation and provides an opportunity to win-win situation despite adverse changes.
- It provides institutional arrangement for mass communication and a way to bridge productivity gaps at local level between farmers by reaching out farmers at their door step.


Photosynthesis
SUN
Light Energy
Oxygen
Carbon Dioxide
Carbon Dioxide enters the leaves through stomata (tiny holes) in the leaves.
Plant Sugars
Minerals
Water


ATMOSPHERE
SUN
1
Solar radiation passes through the clear atmosphere.
2
Some Solar radiation is reflected by the atmosphere and Earth's surface
5
Some of the infrared radiation passes through the atmosphere and is lost in space
GREENHOUSE GASES
4
Some of the infrared radiation is absorbed and re-emitted by the greenhouse gas molecules. The direct effect is the warming of the Earth's surface and toposphere.
Surface gains more heat and infrared radiation is emitted again
3
Solar energy is absorbed by the Earth's surface and warms it and is converted into heat causing the emmission of longwave (infrared) radiation back to the atmosphere
EARTH

THE IMPACT

Unpredictable Climate is a threat to sustainable development: Every single day, there is breaking news about natural calamities hitting some region in the world. This unpredictable climate is creating havoc around the world, destroying habitats and disturbing people's livelihood. Some of the recent natural disasters related to this phenomena in India are narrated below. It must be noted that our country is not new to droughts, cyclones etc., but its frequency and intensity have increased abnormally in the new millennium. India like other countries in the world has its share of natural disasters.

Gujarat Earthquake, 2001

The Kutch earthquake that shook Gujarat was one of the deadliest earthquakes to strike India. The region continues to simmer and has experienced several mild earthquakes and tremors since 2001.

Trail of Destruction

- The death toll : 19,727
- Injured: 166,000
- Homeless : 6 lakhs
- Houses destroyed : 3,48,000
- Cattle killed : 20,000
- Estimated losses at : 1.3 billion

Tsunami December 2004 : affected the Andaman & Nicobar, Pondicherry, Kerala and Andhra Pradesh causing loss of agri-crops, cattle wealth, housing and livelihood.

Mumbai Floods : 26th July 2005 – the city was paralyzed and floods in Maharashtra

Surat Floods (2006) : Estimated loss of Rs.22,000 crore. City's infrastructure affected, high individual losses and crops like sugarcane (Rs. 4,000 crore)

Heavy rains in 2007 in Rajasthan : with flooding and consequent breakout of diseases, loss of crops and cattle wealth.

Bihar : 2008 – Koshi river overflow with dam in Nepal giving way and large areas of Bihar - UP got affected.

Droughts 2009: Delayed monsoon caused drought in some states.

2010 : Heavy floods in Northern India & un-seasonal showers and snow falling in some parts of India like Gujarat in 2010, the most important is that weather has become totally unpredictable.

2011 -13: Floods in Andhra Pradesh so & so far Oddisha, land slide in Uttarakhand.

2014-15 : The monsoon has got delayed.

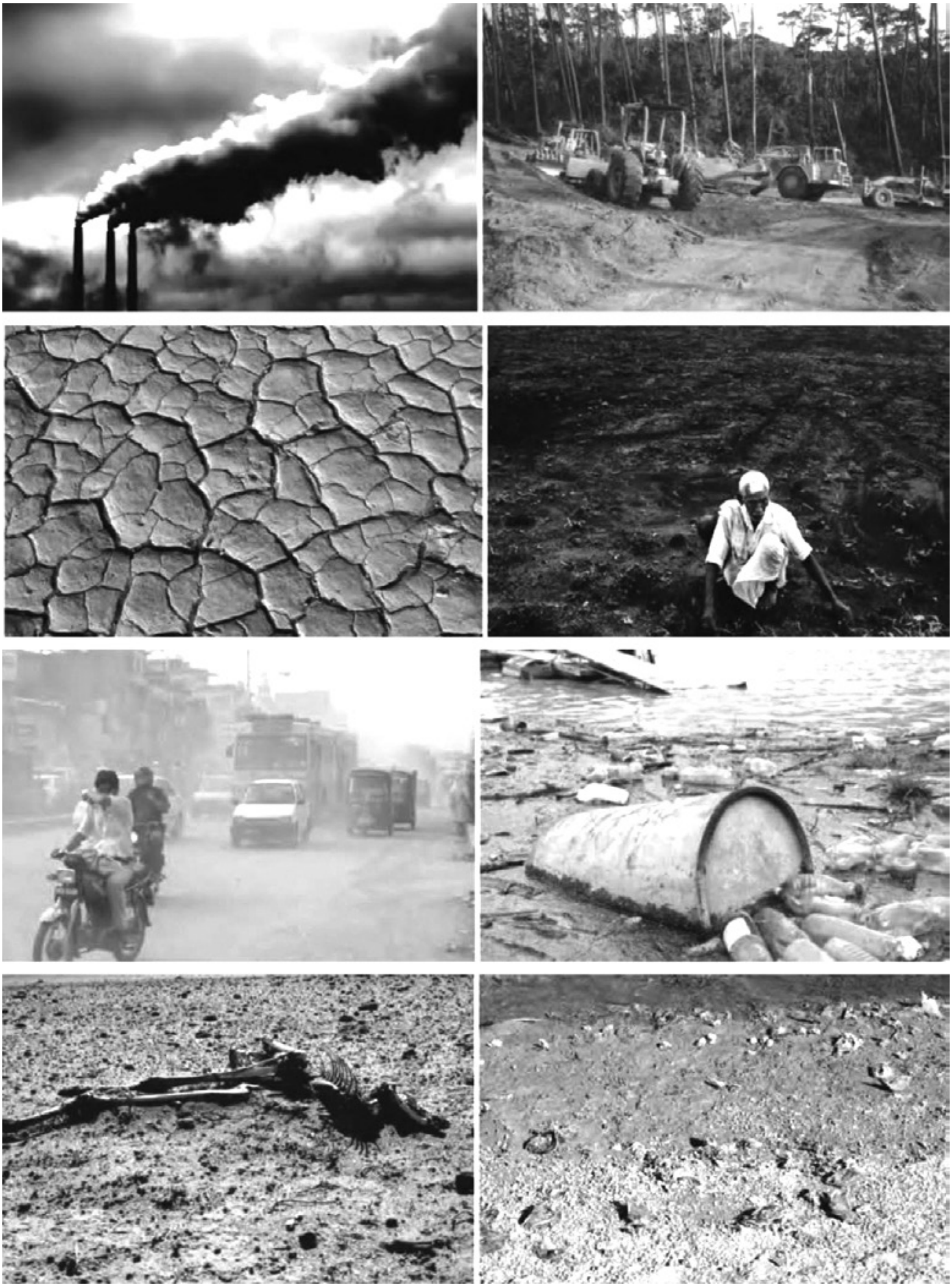
This is continuing year after year with increasing intensity.

Global Impact:

The worldwide impact is equally grave.

- In the U.S. alone, nearly 1,000 tornadoes have killed many people and inflicted $9 billion in damage.
- The 2010 heat wave in Russia killed hundreds of people and led to a 40% fall in the harvest of food grains.
- Floods in Australia and Pakistan killed thousands of people and devastated agricultural lands.
- Re-current droughts in China have eroded millions of acres of farmland.
- Tsunami in Japan – Nuclear plant affected & played havoc to the local habitat
- Recurrent and continuous famines in Ethiopia - Somalia and riots for food by hungry millions.
- Recurrent floods in South East Asia, Philippines, Indonesia, Thailand.
- Almost all nations small or big are affected, one way or another
- This is continuously happening with increasing intensity all across the world.

Effects of Climate Change



Understanding the Impact of Climate Change

Adverse Weather Events – Even a Good Rainfall Year	Cross Cutting Impact
Increased Temperature	Low crop productivity – crop failures
Hot and cold wave	Low productivity in livestock, fisheries and poiltry
Unseasonal frost	Washing away of fields or water logging.
Recurrent droughts in many areas despire good monsoon.	Livestock - poultry-cattle-loss
Recurrent delayed rain	Deterioration quality of harvested produce and loss in quality and quantity.
Increased delay between two spells	Increased attack of pest
Single heavy rain episodes in isolated places	New viral fiver in livestock which also affects human e.g. bird flu-Swine flu
Cyclone	Sprayed fertilizer or pesticides loose impact

Such impacts create:

- Severe famine or heavy floods
- Loss of life
- Loss of agriculture crops and animals
- Loss of livelihood
- Increased risk of diseases outbreak and germination of new viruses.
- Damage to infrastructure and communication particularly in rural areas.
- Setback to social and economic development and emergence of social turmoil with increased rural urban divide.
- Pushing farmers in rural areas again back below poverty line.
- Impact in productivity of various crops, thereby creating a challenge to food security.

Recent research carried out at the Anand Agricultural University - Gujarat provide clue on the deficits that may arise :

Anand Agricultural University – Research on Impact:

Sensitivity of CERES-Peanut (Groundnut) model to ambient temperature under optimal condition (cv. JL-24)

Change in mean ambient temperature (°C)	**Simulated grain yield (kgha-1)**	**% Change from base** (2200 kgha-1) yield
1	2,152	**2.1**
2	1,888	14.2
3	1,514	31.2

The area under groundnut crop in Gujarat is 19 lac ha. Therefore, due to increase in temperature by 3°C, reduction in groundnut yield could be around 31.2% i. e. 13.2 lac ton per year.

Anand Agricultural University – Research on Impact: Sensitivity of CERES-Wheat model to ambient temperature under optimal condition (cv. GW-496)

Change in mean ambient temperature (°C)	**Simulated grain yield (kgha-1)**	**% Change from base (5825 kgha-1) yield**
1	4,078	-30
2	3,675	-37
3	3,266	-44

The area under wheat crop in Gujarat is 24 lac ha. Therefore, due to increase in temperature by 3°C, reduction in wheat yield could be around 44% i. e. 12.5 lac ton per year.

APPROACHES TO CLIMATE SMART AGRICULTURE

OVERVIEW

Climate-smart crop production contributes to food security and this can be accomplished by addressing different aspects of current and projected climate change impacts through adaptation and mitigation actions. Agriculture provides opportunities for adapting to, and mitigating, climate change effects.

Overview of Impact of Changes in Climate

Population of India on the whole has been vulnerable to the impacts of climate changes. The increase in global warming in the last decade and in the forthcoming times is expected to result in the following impacts

- Increase in temperature and extreme heat
- Changes in monsoon pattern
- Increased intensity of extreme weather events – including flooding, rise in sea level.

Such an overall context will lead to significant increase in inter-annual and intra-seasonal vulnerability which may result in

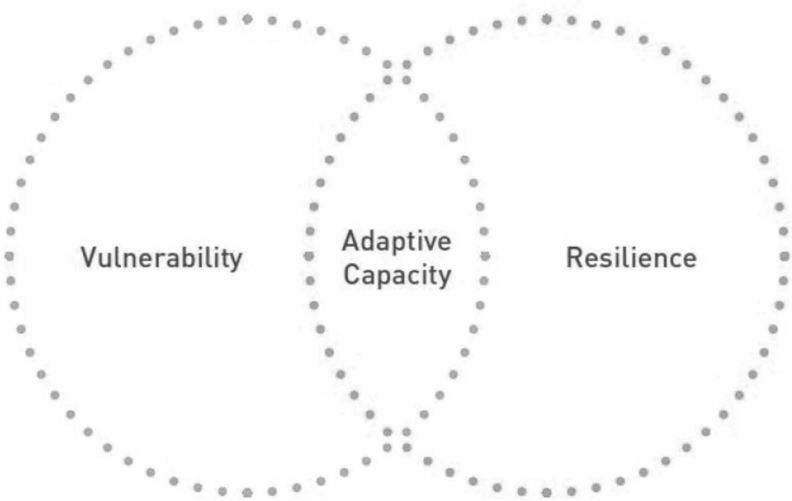
- More frequent years with above monsoon rainfall and year with extremely difficult rainfall is projected.
- An increase in the periodicity of rainfall, with more rainfall during less number of days.
- An increase in number of precipitation events.

Overall impacts can be categorized into three broad areas which overlap on another.

- Assessing changes that have already taken place and its adverse impact and solution needed to have sustainable agriculture
- Contingency Plan – to meet unexpected (but likely) changes that may come during season.

- Restoration strategy for major calamity like high floods or cyclone which destroy habitat – washes away house, fields, check dams etc.

VULNERABILITY AND RESILIENCE FRAMEWORKS LINKED THROUGH THE CONCEPT OF ADAPTIVE CAPACITY



Agricultural systems at risk and response options

Climate impact assessments provide an important interface among science, policy and the public and farmers. Better communication should be encouraged among these three different distinct communities: the climate science community, the impact assessment community and the Climate Smart Agriculture (CSA) community. An effective climate impact assessment must incorporate a wide variety of stakeholders to validate the process, interpret the results and translate them into adaptation and mitigation options that support CSA outcomes.

Source: adapted from Engle, Climate Smart Agri. Source Book FAO-2013

NCCSD APPROACH FOR CLIMATE SMART AGRICULTURE (CSA)

The top-down approach starts from global climate information and moves down to national and state levels for local projections and impact analyses.

The bottom-up approach, on the other hand, considers the present as the point of reference and focuses on social and economic areas of vulnerability or potential impact as a basis for considering future vulnerability at local level. The emphasis is on community-based participatory assessment and action involving stakeholders – understand how they are managing situation? What do they know and what new measures they need to take to have sustainable livelihood.

The NCCSD approach is mix above both.

- First based on available data Experts identify local impact and solutions
- This is followed by Farmers Interaction with Experts. In this, first experts present overall picture and advise what is to be done. This is followed by Listening to farmers to understand:
    - I. What do they know about the climate change ?
    - II. What measures they are taking based on their own knowledge ?
    - III. What they have understood from extension network and followed ?
    - IV. What are their needs – problems ?
- This is further followed by action research to identify the real gap and possible solution.
- All these is converted into simple guidelines which are placed before Expert Committee for vetting it.
- The final step is to develop guidelines based on local input, available practices at international and national level and come out with basic framework of guidelines which farmers can follow generally. These

guidelines are also for other stakeholders – the district level agricultural team, Krishi Vigyan Kendras (KVKs), ATMA, Extension Education Team of State Agricultural Universities (SAUs) and local level leaders – sarpanches, cooperatives, Self-Help Groups (SHGs), APMC and even input dealers.

- This is followed by actual Capacity Building Programmes at Block Level. Farmers are also provided learning material in form of "Guidebook" – known as "Badlata Havamanma Kushal Kheti".
- Finally, at the end of the season, the participating farmers are contacted on sample basis, to know what actual benefit they received and what continue to be remain as problem for which they want solution.
- Simultaneously based on – information gathered and needs identified – the block level and district administration are sensitized for issues related to programme implementation – while the State Government and Central Government are advised about suggestions for strengthening policies and schemes.

SOME BASIC DEFINITIONS

The climate impacts on agriculture are based on historical, present, and future projections under climate Change

'Impact' refers to the effects of climate change on natural and anthropogenic systems. In the case of CSA, the impact will be felt in a variety of areas, including: landscapes, ecosystems, watersheds, infrastructure, farms, agricultural production and markets. The assessment of impacts considers exposure to climate effects and sensitivity to such exposure. It is done in monetary and/or non-monetary terms. 'Vulnerability' is frequently defined as a function of potential impacts (exposure and sensitivity to exposure) and adaptive capacity (Carter *et al.*, 2007; see also Module 1). Exposure is the extent to which the system is physically harmed by climate change. Sensitivity is how affected a system is after the exposure. Adaptive capacity is the system's ability to avoid potential damages, take advantage of opportunities and cope with the consequences of damages.

'Resilience' is the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner (IPCC, 2012). Adaptive capacity is the capacity of people to influence resilience. A system may be made more resilient in a number of ways, including: managing human and environmental components of a system in a manner that maintains the system's *status quo* (e.g. managing water resources to better cope with drought); or transforming into a new system when the current system becomes weak (e.g. eliminating irrigation and agricultural production if drought risk is too extreme).

The vulnerability and adaptation needs of communities are put into context with reference to local non-climatic factors. Vulnerability is considered to be influenced by changing biophysical, social, economic, political, institutional and technological structures and processes.

Source: Climate Smart Agriculture Source Book, FAO - 2013

DOUBLING OF INCOME OF FARMERS

THE ROLE OF PUBLIC LEADERSHIP

Some consider impact on climate change is only related to increase in temperature. But it is much more than that. It also enhances tsunami or earthquakes, increased sea-water level or melting ice – so on so forth. In short it brings about unpredictable changes in weather pattern – which are adverse, which affect livelihood. These impacts have to be understood:

- First is the actual increase frequency and intensity of natural disasters
- Second is the concurrent impact due to change in weather as low or heavy or no rain or impacts increased temperature are on productivity of crops, animal or fish catch.
- Third is unforeseen changes in weather during seasons.
- Finally although Global Warming is international phenomena – its concentrated adverse impact is at local level - village level – on farm land – that it is farmers who suffers most.

We need to take precautionary steps and develop with that continuous action plan. It can certainly be managed by timely action, convergence of efforts and with involvement of all stakeholders. But the role of Public Leadership is key to this. By leadership, we do not mean only political or elected leaders. It includes all members of Public Governance System both elected and non-elected – at the village level Sarpanch, Chairman of Co-operative or Self Help Group, Village Level worker, Teacher. Similarly at Taluka & District level. It also includes Non-Government Organizations involved in Voluntary assistance, Entrepreneurs and even Judges.

In India, Public Leadership has taken climate change and its adverse impact as a challenge.

First it is important to understand the barriers to initiatives and ways bridge them for Doubling of Income of Farmers. These are in addition to adverse impact of climate change that has already taken place and continuing intense adverse weather events.

Barriers to initiative for Doubling of Farmers Income

Poverty: 20% of families in rural area are still below poverty. As per NSO-2013 in Gujarat, 45% and in AP 85% indebted. These farmers do not get access to bank finance – crop insurance – new assets – technologies cannot buy seeds – if germination fails. The govt. has initiated series of initiatives to assist poor. The leadership is needed to provide them access to it.

Share Croppers:

a) Due to increased urbanization – villages are losing identity. Rich farmers buy land in interior area and give work on share cropping basis to original owners.

b) The land on outskirts of urban areas is bought by the developers - original holder becomes share cropper.

In both the situation no fresh investment or bank loan / crop insurance is available. This is growing at a alarming rate. This can be bridged through massive Agro Forestry Programme which could be a pre-condition for non-agriculture use.

Loss of Farm Produce

- **Farm Level**

  Farmers loose between 5% to 25% of agriculture produce due to inefficient and un-scientific Practices like:

  - Untimely harvest
  - Loss due to open thrashing – sometime even on road.
  - Dispatch to Market : Packaging and transporting in bags with holes

- Storing harvest produce in open before bringing to home/godown.
- Unhygienic storage. Using transport carrier – Tempos, which also transports pesticides – kerosene – oil affects quality of produce as it catch bad smell. Some vegetables-fruits are placed at bottom – while food grain bags on top crushing vegetables.

Current Situation:

- Recognize that we have done well. We have sustainable agriculture growth. Poverty has declined from 90% to 20%. We should be proud of this. In fact in Gujarat Farmers have had doubled their income in last decade. In fact in the year 2016-17 country had highest production of Food Grains and output of Pulses increased by 20%.

The Country has stable Agriculture Growth and the Government has taken very many new initiatives to enhance it:

- o Liberal Crop Insurance, even non-loanee farmers are covered
- o E Marketing – reform in Spot & Derivative Market.
- o Integrated irrigation scheme – micro irrigation – watershed, river basin – river linking.
- o Introduction of Soil Health Card – selection of crop based soil health – crops that can be sustained by soil.
- o Assured Employment in community and in some cases in personal farmland.
- o Food Security
- o Multiple Skill Initiative and so on

What precisely is challenge?

- We want to provide sustainable livelihood to all our families:

  This means – that one should have;

  - Enough to live and survive
  - Income should not become less
  - Income increases gradually on par with other sector of economy. As continuing difference of income of rural rich and rural poor and rural families and urbanites is causing social and economic turmoil – resulting into farmers' agitation.

- **Hence Hon'ble Prime Minister has given target of doubling income of farmers – remove the in-equity and disparity.**
- Challenge is to increase – doubling income of farmers in Arena of Climate Change and face challenge of increasing threat to food security and enhancement poverty in rural areas. For example due to recurrent

droughts average yield of food grain in Gujarat is in decline. As per report Nav Gujarat Samay, it has come down from 2097 kg per ha – in 2013-14 to 1552 kg per ha in 2016-17. The other data reveal that food grain production declined from 100 lakhs tones in 2010-11 to 79.47 lakhs tones in 2014-15. This shows how serious is the challenge-Even in Gujarat which had doubled its income between 2003-04--2012-13.

- At national level also situation was same – country was required to import wheat after gap of many years. The average growth rate is below 2 per cent in last two years (2014-15 and 2015-16)
- Hence it must be realized that Agriculture Sector of country as a whole is still vulnerable – so are farmers. In order to double their income in such a situation – when even after so many years of development we are dependent on good monsoon – more concerted efforts and a serious action plan is needed at local level - with strong Monitoring.
- This is also a serious message to our Agricultural Scientists – The Agricultural Universities and ICAR and District Administration.

This book is an endeavour to bring out how farmers themselves can manage such situation to their advantage. It is also meant for Extension Team which inter-acts with farmers and guides. They can make available this knowledge to those who do not have access to this knowledge.

The book provides step by step approach and alternative choices – if followed – one can easily have sustainability with increasing income and farmer will no longer left behind his urban counterpart.

WATER CYCLE

Understanding impact of Climate Change on Water Cycle for Agriculture

Even without climate change, underground water resources are reducing due to high discharge by tube wells – both for agriculture in rural areas and for managing increasing daily urban needs.

With the temperature increase due to higher rate evaporation etc., there will be reduced water availability. This will also reduce "Soil Moisture" having direct impact on crop productivity and its sustainability. This causes drinking water scarcity for cattle and human being and require migration plan. Rise in sea – level is already being experienced in Gujarat villages of Dandi – Navsari, Cambay – Anand. This is a) resulting into direct loss of agri. Land b) salinity ingress in sub-soil strata affecting root zone. Further inundation from flood causes wipe out surface soil from the land surface.

WATER CYCLE

Vulnerability of Areas - Gujarat

Major agricultural systems	Vulnerability			Typical response Main climate options
	Main Climate Change Exposure	Sensitivity	Adaptive capacity	
Kutch	Rainfall variability, droughts, floods	High: mostly rain fed agriculture, marginal lands, poor soil moisture capacity	Low: high prevalence of poverty, limited options, knowledge, social safety nets and resources	Watershed management and on farm water storage for water conservation; Integrated water resources management in river basins; investment in social infrastructures
North Gujarat	High temperatures, rainfall variability, droughts	High: crop and animal sensitivity to high temperature and droughts, high population density on marginal lands	Low: high prevalence of poverty, limited options, knowledge, social safety nets and resources, limited capacity for water storage	On-farm water storage; crop insurance; increased productivity through better crop-livestock integration; integrated water resources management

Major agricultural systems	Vulnerability			Typical response Main climate options
	Main Climate Change Exposure	Sensitivity	Adaptive capacity	
Valsad Navsari South & Middle Gujarat	Reduction in annual rainfall, increased rainfall variability, reduction in runoff and aquifer recharge, high temperatures, higher occurrance of droughts and floods	Variable, depending on the region and level on reliance on agricultural activities. Agricultural systems highly sensitive to changes in temperature and water availability.	Low adaptive capacity for agriculture in water scarce areas	Water conservation where possible; integrated water resources management; crop insurance; improved floods and drought management plans; shifting out of agriculture
Junagadh Saurashtra Region	Increased rainfall variability, reduced water availability in places.	Medium to low. Some high yielding varieties more sensitive to temperature and water stress . Rain-fed agriculture	Possibilities to compensate water stress through supplemental irrigation in many regions; low capacity in water scarce areas	On-farm storage for supplemental irrigation; integrated water resources management at river basin level

Source: adapted from CSA source, FAO 2013

Climate change and its impact on water cycle

Element of Water Cycle	Climate Change
Annual precipitation	Expected to increase globally during the 21st Century, with potentially great spatial variations
Interannual variations in precipitations	Expected to increase everywhere
Seasonal variability of rainfall	• Expected to increase everywhere • Delayed monsoon • Interim delay within season
Soil moisture stress (droughts)	Moisture stress to generally increase as a result of increasing variability of rainfall distribution (longer periods without rain) and increasing temperatures and deplete soil moisture faster than natural vegetation
Floods	Increased as a result of increasing frequency and intensity of extreme rainfall events flood intensity can affect standing crops, washing away of upper fertile crust of soil & cause soil erosion
River discharge	Increased variability as a result of changes in rainfall patterns. Changes in annual runoff expected to vary from region to region
Groundwater	Varies as a function of changes in rainfall volumes and distribution. Impact is complex, with floods contributing to increasing recharge, and droughts leading to increased pumping
Evapotranspiration	Increases as a function of temperature increases
Water quality (in rivers, lakes and aquifers)	Moderate impact through temperature increase
Salinity in rivers and aquifers	Potentially high impact where sea water level rise combines with reduced runoff and increased withdrawal

Source: adapted from a comparative analysis of Turral et al., 2011; Comprehensive Assessment, 2007

Options for climate change adaptation in improve water cycle

Option	Field / farm	Irrigation scheme	Water-shed / aquifer	River basin	National
On-farm water storage: water harvesting, farm ponds	X				
Groundwater storage in community ponds	X				
Modernisation of irrigation infrastructure check dam		X			
Dam construction/enhancement/ repairs		X	X	X	
Drainage and cleaning of drains and canals	X	X	X	X	
Introduction integrated River Basin Management	X	X	X	X	X
Linking rivers and irrigation canals	X	X	X	X	X
2. Land, water and crop management					
Enhancing soil moisture retention capacity	X				
Changing cropping pattern and diversification	X				
Adapting cropping (and fish harvesting) calendar	X				
Supplementary irrigation	X	X			
Deficit irrigation		X			
Alternate wet and dry rice production system		X			
Adopting Drip Irrigation	X				

Source: adapted from Turral et al., 2011, CSA, FAO 2013

Most of these options are part of development programmes. Options for on-farm water conservation have been promoted for a long time as a response to water scarcity and climate variability which are a part of rural development programmes and marked under watershed management and NAREGA Scheme.

Options to address increasing water scarcity through better participative management of water at river basin are needed in many water-stressed areas as exemplified in the below case study of Rukmavati River.

A Landscape approach

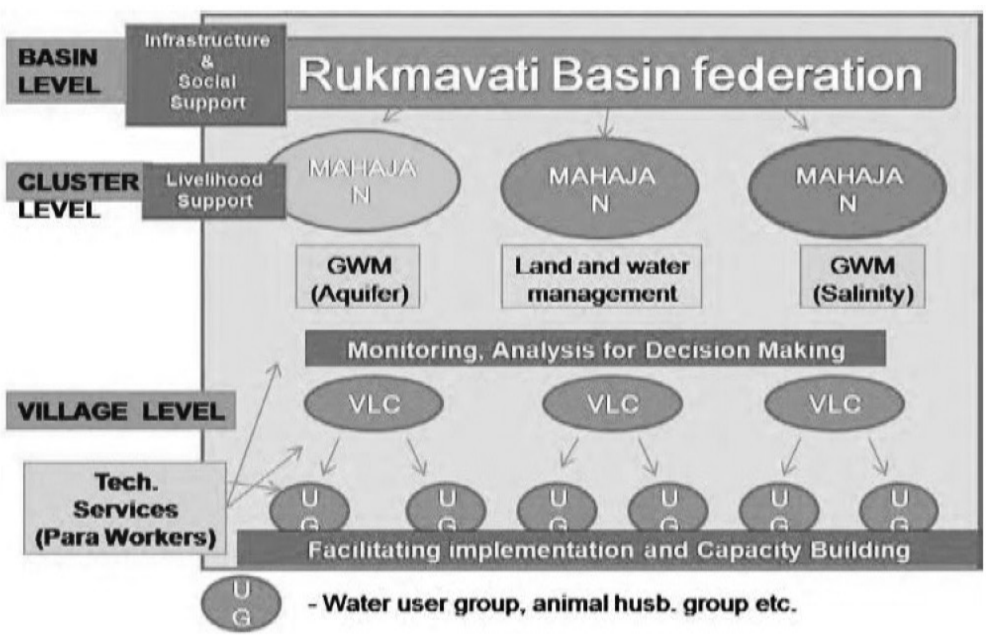
Case study of intigrated River Basin Management in Arid area.

Rukmavati River Basin – Mandvi – Kutch an arid district - Gujarat

Implementing Agency – Shree Vivekanand Research and Training Institute (VRTI) led by Shri Ashwin Shroff and Shri Jayprakash Gosalia in convergence with Government Departments, Local Leadership & Farmers

Rukmavati River Basin Profile & Resources

- Land holder / Number of farmers : 10,554
- Farmers engaged in rainfed agriculture could grow only 1 crop under optimum rainfall



- Yield gap in agricultural productivity– average yield compared to optimum yield: -10 to -40%
- Value of current agricultural production: Rs. 172 crore
- Yield gap in cattle productivity– average yield compare to optimum yield: -25 to -40%
- Value of current milk production: Rs. 36.5 crore

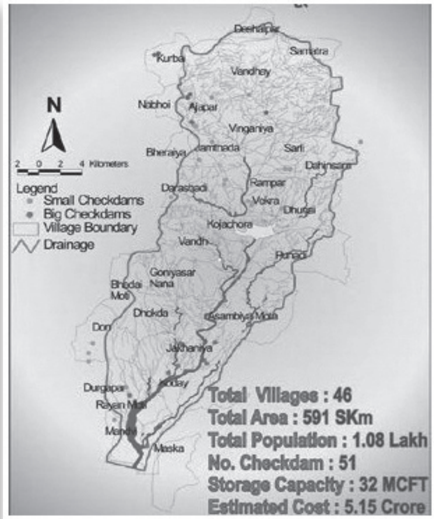
The main concern is depletion of water resources. The Integrated River Basin Management is an approach to meet this challenge. A step ahead of the existing watershed approach, it is a process of co-ordinating conservation, management and development of water, land and related resources and agro industries across sectors within a given river basin. An integrated approach using the whole River Basin as a basis for holistic & sustainable planning, can provide a solution to ensure economic, social and environmental sustainability and ensure food & water security and generate wealth in rural areas through value addition by local processing of agri-produce and thereby largely aiming remove disparity

Aim:

- Create an integrated and sustainable development rural habitat on Rukmavati river basin

Objectives:

- Understand potential of various natural resources like water, land, vegetation etc. within the basin.
- Educate the stakeholders about the situation
- Understand issues and challenges of the river basin management.
- Institutionalize decentralized and people centered resource management mechanism
- Generate economic well being along with human well-being and environmental well-being
- Manage micro climate in the basin area



Over flowing check dam in basin area

Approach & Methodology

There are four phases of the entire project:

- Community Awareness
- Planning
- Implementation
- Management

However, there is overlapping of activities of these phases

Major problems

- Over exploitation of ground water has resulted in acute depletion of water level in Mandvi block, it is has also been declared as dark zone
- Ground water quality is degraded i.e. TDS - 3000 to 10000 ppm
- Degradation of agricultural land and reduced productivity
- Soil erosion in basin area due to mining activity
- Due to unequal allocation of resources like water and land, difference in socio economic condition

Focused Activities

- **Water Harvesting**
  - Check dam
  - Renovation of old structure
  - De-silting
- **Soil moisture conservation**
  - Continuous contour trench
  - Staggered Trench
  - Silt Trap
  - Farm pond
- **Agriculture/ Horticulture**
  - Farm bunding
  - Land leveling
  - New plantation
  - Drip irrigation
- **Forest area development**
- **Animal Husbandry**
  - Grass land development
  - Cattle feed units
  - Milk collection units
  - Veterinary services
  - Fodder collection and storage
- **Training and awareness**
  - Farmers training
  - Women - Self-Help Groups (SHGs)
  - Workshop/Seminar
  - Exposure visits
  - Promoting locally marketing
  - Promoting young educated farmers to set up micro-enterprises

key to entire programme is convergence of all Government schemes, with involvement of local Public Administration - both elected and non-elected members, all Govt. departments, & organisation, local non-elected leaders and, of course, farmers and animal holders. Young persons and women are actively involved.

Impact

Improvement in Agriculture

- Improvement in crop productivity due to improved water quality.
- About 250 hectares of land benefited and there is about 10-15% increase in crop productivity (cotton)

Implementation

- Activities as per strategy have been carried out through linkages with Government Departments and other institutions like Agrocel, Kutch Crop Services, Rukmavati Rural Agro Producers Company and other funding agencies
- *Mahajan* – Representative from each village - is involved in each stage of implementation
- To implement programmes of the government Gram Panchayats have been actively involved to choose beneficiaries

Progress 2010 - 2016

- Rukmavati river basin project - implementation of activities: Based on participative planning with involvement of local community, different activities are implemented through linkages with various agencies such as UNICEF, CARE India, various government departments.
- Construction of new check dams: 68 new check dams have been constructed with storage capacity of 35 MCFT (Million Cubic Feet). The total investment was Rs. 80 million (Indian Rupees). Due to construction of these check dams 1625 farmers got benefit of water security and provided irrigation assurance to 3364 hectares of land, reducing dependency on ground water. Improved ground water recharging prevented sea water intrusion in aquifer.
- Desilting of existing structure: In tank /dam siltation is very common after influx of new water during rainy season. Silt deposition reduces storage capacity of structure. Desilting (silt removal) is necessitated to restore original storage capacity. Application of this silt in nearby farm land improves soil fertility and reduced requirement of chemical fertilizers. Desilting was carried out in 32 structures with investment of Rs. 6 million, benefitting 196 farmers and 379 hectares of land.
- Pasture development: In rural India, animal husbandry is complementary to farming and very important source of livelihood by providing regular income. Village pastures are major source of fodder requirement of animals. With increased intensity of rainfall, quick water runoff will lead to poor grass development. To cop up with this problem, development of pasture land with different soil moisture conservation measures like contour trenches, staggered trenches were carried out. This activity was carried out in 473 hectares of land with investment of Rs. 36 million.
- Composting: Farm and animal waste when properly composted is good source of plant nutrient for applying to soil. Generally farmers burn farm wastes which add CHG to atmosphere. VRTI influenced farmers to exercise composting of waste for soil improvement. This activity was carried out with 36 farmers.
- Drip Irrigation : Use of drip irrigation system is one of the methods to improve irrigation efficiency. In the project area, awareness campaigns were carried out by VRTI to promote drip irrigation system. 146 farmers have installed this system in 329 hectares of land with investment of Rs. 3.6 million.

- Farm bunding: To conserve soil moisture and check soil erosion, farm bunding activity has been carried out. Total 40 hectares of land has been covered under this activity thereby; improvement of productivity by 8 - 10%.
- Horticultural plantation: This activity has been promoted in around 200 hectares of land. Plantation of Date palm, Pomegranate, Mango, Ber, Banana and Papaya have been carried out with drip irrigation technology. This plantation will provide round the year green cover and more income to farmers.
- Women empowerment through micro finance activities: 56 Self Help Groups (SHGs) were formed and 765 women have initiated monthly saving and microfinance related activities. Till date saving of these women is around 1.2 million INR (Indian Rupees). This activity has developed leadership skills and social status upliftment for women.

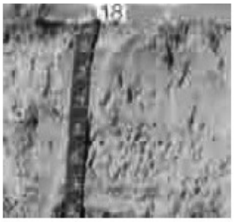
The concept of river basin management is a unique approach for sustainable development which focuses on particular geographic region having natural boundary. Understanding of natural resources of basin area and conservation, management and development of these resources is prime focus of this approach. The concept of river basin management is definitely replicable to such river basins particularly of rainfed areas but with little modification can be very usefully applied to flood prone areas - which is a major problem in many parts of our country.

The current watershed approach which was very well conceived, now needs to be expanded to include overall Riverbasin Management to ensure that every drop of water which is received is usable and is used for improving productivity & multiplying crop production.

SOIL MANAGEMENT

The soil has direct impact of changes in climate and that in turn affects productivity – sustainability of crops that grow on it.

Soil & Climate Change

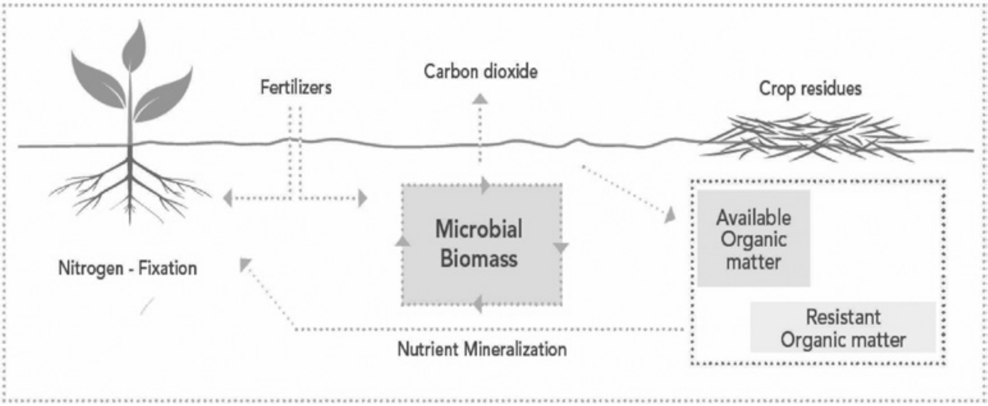


Life support services	Provision services	Regulating services	Cultural services
• The soil renews, retains, and delivers plant nutrients and provides physical support to plants. • It sustains biological activity, diversity and productivity.	• Soil is the basis for the provision of food, fibre, fuel and medicinal products that sustain life. • It holds and releases water for plant growth and water supply.	• The soil plays a central role in buffering, filtering and moderating the hydrological cycle. • Soils regulate the carbon, oxygen and plant nutrient cycles (e.g. nitrogen, potassium, phosphorus, calcium, magnesium and sulphur) that affect plant production and the climate.	• Soil provides the foundation for settlement and infrastructure. • Soils and their wider ecosystems provide spiritual or heritage value. • Soils are the basis for landscapes that provide recreation.

• The soil ecosystem provides habitat for the dispersion and dissemination of seeds, which ensures the continued evolution of the gene pool.		• Soil biodiversity contributes to regulating soil pests and diseases. • Soil micro-organisms process and break down wastes and dead organic matter (e.g. manure, remains of plants, fertilizers and pesticides) preventing them from building up to toxic levels and entering the water supply as pollutants.	

Source: Climate Smart Agriculture Source Book, FAO - 2013

- Soil health depends on its capacity to provide the basic services for supporting plant growth and contributing to the regulation of nutrient, water, carbon and gaseous cycles.
- Soil health is widely linked to soil biodiversity. Soil organisms mechanically and chemically (mineralization) break down the organic matter so they can use it as food. Excess nutrients are released into the soil and used by plants.
- The recalcitrant (indigestible) fraction of the organic matter is reorganized into Soil Organic Matter (SOM), which is less decomposable than the original plant and animal material (Figure). In turn, SOM content, especially the more stable humus, increases the soil's capacity to store water and sequester carbon from the atmosphere (Bot and Benites, 2005).
- A soil's productivity depends on its physical, chemical and biological properties. Of particular importance are its mineral composition, organic matter content, soil life and associated biological activity. Sandy soils are the least productive as they do not have the capacity (unlike clay soils and silty soils) to retain moisture and nutrients through chemical attraction (electrical charge). However, sandy soils can be managed productively even



Source: Gupta *et al.*, 1997, CSA, FAO 2013

in hot, dry climates if there is access to required water, organic materials and fertilizers to nourish plant growth.

Soil Health Card

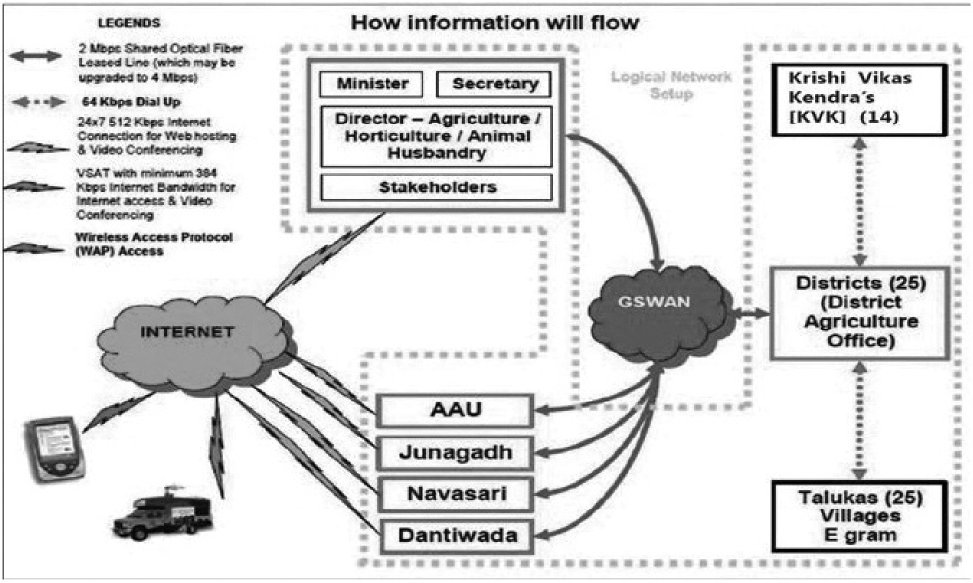
It is now increasingly realized that the impact of climate change is on Mother Earth the land or its content - the soil.

- The increase in temperature is absorbed by soil
- Lack of rainfall or less rainfall reduces its moisture content
- Heavy rain or floods impair its upper crust

In cropping, grazing and forest systems, in particular, climate change and variability may affect soil health for plant growth through:

- reduced or erratic rainfall and more frequent and severe periods of drought that lower the capacity of soils to make water and nutrients available to plants;
- more intense rainfall and storms that increase the risk of soil erosion by water and wind (through rain splash, accelerated runoff, strong winds); and
- increased soil surface temperatures and greater rates of mineralization of SOM.

All these affect the fertility of soil and its capacity to sustain even existing crop- pattern. These in turn affect productivity with low yield or crop failure. This can cause decline in food production and endangers food security to hungry millions. It is realized that analysis of soil chemical content and micronutrients, soil health reveals its need of nutrition to be supplemented



(7) Crop wise fertilizer recommendation based on soil analysis report
(For Individual field)

Season/ Crop	Department's General Recommendation for fertilizer (N.P.K/Hector)	Recommendation based on soil analysis			
		FYM (Ton/H)	Nitrogen (Kg./H.)	Phosphorus (Kg./H.)	Potash (Kg./H.)
1. Monsoon					
Banana	180: 90: 180 (Gr./Plant)	15	200	90	180
Jowar (Fodder)	75: 40: 0	15	85	40	0
Paddy (Early)	80: 30: 0	12	90	30	0
Paddy (Medium)	100: 30: 0	20	110	30	0
Paddy (Late)	120: 30: 0	20	130	30	0
Tobacco (Monsoon)	180: 0: 0	25	200	0	0
Til (Semi Winter)	20: 25: 0	10	55	25	0
Till (Semi Winter)	12: 12: 0	10	12	12	0
Hybrid Bajri	80: 40: 0	25	90	40	0
2. Winter					
Wheat	120: 60: 0	25	130	60	0
3. Summer					
Summer Bajari	120: 60: 0	25	120	60	0

SOIL HEALTH CARD
AGRICULTURAL DEPARTMENT
GUJARAT STATE

Soil Health Card No. : SHC00027842

(1) Farmer's Name : Mr. Purshottambhai Hirabhai Patel
(2) Village : zarola Taluka : Borsad District : Anand
(3) Account No.: 280
(4) Land/Soil detail as per account :

Sr.No.	Survey No.	Area (Hector)	Soil Type
1			
2			
3			

(5) Soil Fertility Status based on the analysis of the village soil.

Sr.No.	Fertility	Nitrogen	Phosphorus	Potash
1	Low			
2	Medium			
3	High			

(6) Soil Analysis Detail of individual field : Survey No. - 1004-2

Sr. No.	Detail	Result	Explanation of the result
1	pH Value (Soil reaction)	7.20	Normal
2	EC (Electric Conductivity) (millimous/cm)	0.49	Normal
3	Organic Carbon (%)	0.26	Low
4	Available Phosphorus P2O5 (Kg/ha)	43.00	Medium
5	Available Potash K2O (kg/ha)	254.00	Medium

	pH	*EC (Electric Conductivity)*	
Acidic	*<6.5*	*Safe*	*< 1.0*
Noarmal	*6.5 to 8.2*	*Saline*	*1.0 to 3.0*
Basic	*> 8.2 (Gypsum to be used)*	*Harmful*	*> 3.0*

Soil Health Card – Gujarat

Source : What Ails Our Agriculture? - Dr. Kirit Shelat by organic or/ and inorganic manure – so that it can generate appropriate yields and can sustain the fertility of soil – along with Soil Management.

Further, with that addition of Moisture Analysis can indicate the crops it can sustain. All crops cannot be grown everywhere. Each piece land has its distinct soil health that indicates fertility and capacity to sustain crops.

Hence, Soil health & Moisture analysis is the key to provide guidance about sustainable crops that can be grown on individual piece of land because it provides data about:

a) The alternative crops that can be grown this along with details of average price of same in local market and farmer can make informed decision.

b) The gap in nutrients in soil to maintain fertility and actual mix needed of organic and in-organic

This can be initiated at village/block based. But in reality soil texture and structure varies across survey numbers in a village. Hence, it has to be individual survey number-based for individual farmer. In that way individual farmer can be guided – by written guidance in form of soil health card – which most farmers act on.

In Gujarat this is already under implementation since year 2004 and more than 40 lacs farmers are covered. The Anand Agricultural University has Central Computer Centre – which linked through internet with all other universities and block level. Farmers can access information on website. Once the soil data is fed in the system, automatically analysis is generated.

As mentioned soil absorbs the impact of changes in climate - Hence, it is essential that farmers get these analysis every year and in case of flooding of field and after the water is drained out.

Soil Health Card is a key to climate resilient crops. Further, since it is written guidance given in form of card farmers invariably followed and benefited. It is a comprehensive new extension approach to provide individual farmer a written guidance for his individual piece of land in contrast to current system which provides contact farmers oral guidance. Due to changing weather parameters, soil content get affected and hence, this is required to be done every year. With modern Information and Communications Technology (ICT) network - this is feasible.

Soil management for sustained crop productivity and climate change adaptation and mitigation

Conventional practices	Practices to enhance Productivity and Adaptation	Practices to enhance mitigation
Soil tillage for annual crops: Hoeing or ploughing improves the seedbed and uproots weeds. However, it disturbs microbes, destroys soil drainage created by soil fauna (e.g. earthworms), speeds decomposition of organic matter and releases CO2. It may develop a compacted layer or hardpan which impedes plant root growth and rainwater percolation.	• Conservation agriculture systems are practiced advice. It involves three principles: • Minimizing soil disturbance (no-tillage) through digging sticks or jab planter to plant seeds or mechanized direct drill systems (mechanized systems have been developed to drill the seed through a vegetative layer and may use herbicides to manage weeds). • Keeping the soil covered with a protective layer of mulch or crop residues which reduces weed growth, reduces moisture loss, keeps the soil cooler, reduces erosion by water and wind and restores soil carbon (C) through decomposition. • Rotating and diversifying crops to reduce crop pests and diseases and use leguminous species to replenish soil nutrients.	The sequestration potential increased after adoption of improved management practices. Although there may be slight negative GHG impacts from application of additional chemical herbicides for weed control instead of weed control by tillage.

Conventional practices	Practices to enhance Productivity and Adaptation	Practices to enhance mitigation
Fertilizer use: A shortage of any one of the nutrients required for plant growth can limit crop yields. Increased productivity is needed to meet current and future food demand. Balance us of fertilizer to meet this. But dealers provide bulk fertilizer bags and farmers tend to use more than needed. It increasing cost of cultivation and nutrients are not taken up by the crop but released into water bodies and emitted into the atmosphere – which releases GHG into the atmosphere.	Integrated Soil Fertility Management (ISFM) aims to make available required soil nutrients by balancing different on farm soil organic sources (amendments) with nutrients from mineral fertilizers (to address deficiencies) and reducing nutrient losses through soil and water conservation based on recommend made by soil & health moisture analysis	Nitrate leaching from overuse of mineral fertilizers also increases nitrous oxide emissions add to GHG emission. Options to reduce losses and emissions include: • change the fertilizer source from ammonium-based to urea, or switching to slow-release fertilizers; • placement of fertilizer N near the zone of active root uptake;

Conventional practices	Practices to enhance Productivity and Adaptation	Practices to enhance mitigation
Crop specialization and annual harvesting: Many crop production systems progressively decrease SOC as most plant growth is above ground and is removed at harvest. Often crop residues are removed for fodder, fuel for industrial applications or are burned for pest control (e.g. cotton).	Organic agriculture systems do not use inorganic fertilizers or pesticides but use crop rotations and mixed farm strategies, with mulch / composts / animal manures /green manures to replenish soil C, improve nutrient cycling and use by plants and suppress weeds. The enhanced biodiversity reduces pest outbreaks and severity of plant and animal diseases. Increasing the use of perennial crops and maintenance of shrubs and trees in the farm landscape improves soil resilience and provides diverse products (food, fuel, fibre, timber, etc.) while supporting ecosystem services. Appropriate agro-forestry systems that integrate crops trees with crops and restore SOM and N. They enhance diversity, build healthier soils, enhance crop and fodder production. Some species provide fruits, timber and fuel-wood or bio-energy. They can also reduce erosion and provide water quality and habitat benefits through shade and deep rooting, hence enhancing resilience to climate change.	Decisions to irrigate should be a factor in the consideration of the cost and GHG implications of mechanized systems. Perennial crops and trees can sequester substantial amounts of C and can store C for longer periods than annuals in the biomass of roots as well as in stems and branches. The frequency of tillage is reduced, protecting SOC and other soil functions. Other soil management options in cropping systems include breeding deep rooted crops and managing fallow periods to increase soil C stocks. The C sequestration potential of agro-forestry varies widely, depending on the specific practice, individual site characteristics and the time frame.

Conventional practices	Practices to enhance Productivity and Adaptation	Practices to enhance mitigation
Soil crusting and degradation in dry-lands: This is a severe problem in Kutch – Combay, Tarapur (Anand) and Dandi due to wind erosion and loss of SOM due to high temperatures and burning. When rain falls it can no longer infiltrate the soil and the region becomes increasingly barren and arid.	In kutch – under watershed programmes and prevention of salinity ingress programmes – check dams, bandh, village, ponds, farms ponds, gully plugging and protection wall have been successfully used to meet this challenge. The latest approach integrated is river basin management in Rukmavati river basin.	Kutch Examples – are in case studies
Soil puddling in rice paddy systems: Creates anaerobic conditions and increases emissions of GHGs. Flooded rice fields globally represent one of the main sources of methane.	Systems of Rice Intensification (SRI), which are further elaborated in the column on the right, bring benefits also in terms of productivity and adaptation, e.g. by improving the growth and performance of rice crops and subsequently increasing yields. This is successfully implemented in Anand block of Anand district – but needs to be replicated in all blocks.	• SRI, an approach requires compliance with the following: i) moist (but well drained and aerated) soil conditions; ii) transplanting rice seedlings at a very young age; iii) wider spacing of plants; iv) use of organic matter (i.e. compost made from any available biomass and manure if available) and chemical inputs; and v) frequent weeding.

Source: Soils and their management for CSA – Climate Smart Agri. Source Book

RAINFED AGRICULTURE – SOIL MOISTURE CONSERVATION

- Tropical and subtropical rainfed agriculture depends on an adequate supply of water in the rooting zone of the soil
- Adequate moisture availability is a problem in the subtropical and tropical agro-ecological zones with irregular or seasonal rainfall
- Occurrence of timely rainfall in sufficient quantity is the prime requirement for successful rainfed agriculture because it can reduce crop yield and quality
- Capturing rainwater where it falls and storing it in the root zone is the most cost-effective means of increasing

Soil Moisture Conservation Practices

The main objective of soil moisture conservation is to minimize the amount of water lost from soils through: 1. Evaporation - Water loss from soil 2. Transpiration - Water loss through plants or evapotranspiration

Methods for reducing soil moisture loss and direct sun exposure to heat and sun:

- Spreading manure or compost over soil – minimizes evapotranspiration and provides nutrients to soil
- Mulching – Mulch is a layer of material placed in the root zone of plants. Ex: straw, wood chips, peat, plastic sheeting
- Conservation tillage – reducing or eliminating tillage to maintain soil organic levels to increase soils capacity to absorb and retain water
- Crop rotation – Growing different types of crops to improve soil structure and water holding capacity. Ex: Rotating deep-rooted and shallow rooted crops that make use of previously unused soil moisture.

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by Dr Mehboob B Sheikh- FAMU

- Green manuring – growing of plant materials with the sole purpose of adding to the soil for improved organic matter and nutrients.
- Deep tillage –Deep tillage to increase porosity and permeability of soil to a combination of crops with different planting times and different length of growth periods
- Contour ploughing – Ploughing the soil along the contour instead of up- and down-ward slopes
- Strip cropping - growing erosion permitting crops and erosion resisting crops in alternate strips

CROP SELECTION STRATEGIES

- Identification of suitable moisture conservation method should be determined by matching rainfall with crop requirements.
- The Three Situations:

1. **Where precipitation is less than crop requirements:**

   The strategy should include (a) land treatment to increase run-off onto cropped areas, (b) fallowing for water conservation, (3) use of drought-tolerant crops

2. **Where precipitation is equal to crop requirements:**

   Here the strategy is (a) local conservation of precipitation, (b) maximizing storage within the soil profile, (c) storage of excess run-off for subsequent use

3. **Where precipitation is in excess of crop requirements:**

   The strategies are to (a) reduce rainfall erosion, (b) drain surplus run-off, (c) storing for subsequent use.

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AMELIORATION OF WATER-DEFICIT STRESS

1. **Adaptation of Drought Tolerant Crops:**

   Improvement in dryland production systems requires introduction of species already adapted to these stresses, example: Pearl Millet, sorghum, moth beans

   Cereals

   - Pearl millet is the most drought tolerant crop with higher water use efficiency and better adapted to dry nutrient deficient soils
   - Pearl millet has strong deep root system and short life cycle. It can survive where mean annual precipitation is as low as 250 mm as compared to minimum water requirement of 400 mm for sorghum and 500-600 mm for maize
   - Sorghum and pearl millet are traditionally grown as rain-fed crops under extreme harsh conditions
   - Pearl millet is also more salt tolerant than sorghum and is the second most salinity tolerant major cereal after barley

2. **ADAPTATION AND SELECTION OF CROP VARIETIES**

   Legumes

   - Moth bean, mung bean, cluster bean, horse gram and cowpea
   - Mung bean and moth bean are drought tolerant. Mung beans shows escape

     mechanism due to short growth.
   - Moth bean is highly drought and heat tolerant.

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Adaptation of Early Maturing Varieties

Varieties suitable for different regions of Gujarat

Legume	Variety	Duration
Cluster Bean	HG-563 GG-2 HG-365, RGC-936,	80-85 95-100
Cowpea:	GC-3 GC-5	90-95 75-80
Horse gram	AK 21 , AK 42	

3. **Regulated Deficit Irrigation**
   a) Alternate partial root-zone irrigation where the two neighbouring plant rows. In every four rows are irrigated and they are shifted in consecutive irrigations
   b) Fixed partial root-zone irrigation where the two neighbouring plant rows in every four rows are irrigated every time and the remaining two rows of plants kept in drying soil
   c) Subsurface irrigation where irrigation is applied in the lower part of the root zone
   d) Dripper systems are used to provide supplemental water under plastic film cover at critical growth stages.
   e) Some of the plant rows are irrigated, and the other plant rows left unirrigated are mulched with plastic films.
   f) Alternate plant rows are irrigated, and the other plant rows left unirrigated are mulched with crop straw.
4. **AMELIORATION OF WATER-DEFICIT STRESS**
   - Water-deficit stress can be alleviated through management practices such as early planting and irrigation
5. **Use of Plant Growth Regulators (PGR) :**
   - Glycine Betaine: Foliar application of glycine betaine has been reported to enhance drought tolerance and yield in maize, tomato, tobacco, and wheat

- Salicylic acid: A plant hormone that is known to induce drought tolerance and improve yield
- PGR-IV : Increases root growth, nutrient uptake, boll retention and lint yield of well-watered cotton
- Hick1-Methylcyclopropene (1-MCP), has a positive effect of water-stressed cotton leaves
- Use of Plant Growth Regulators has the potential to ameliorate water-deficit stress in crop production

RESTORING DEGRADED SOILS AND USING WASTELAND & WETLAND FOR CLIMATE CHANGE RESILIENCE

The world's soils are estimated to have a high potential for carbon sequestration because SOC content can be effectively conserved and also readily restored or increased through appropriate land uses and agricultural management practices which can potentially be applied at landscape level (Corsi *et al.*, 2012).

Taking a care from successful experiments in India and abroad a large number of non-cultivable wasteland, cultivable fallow land and marshy areas can be brought under vegetation cover. India has vast tracks of such lands on margin areas of deserts and inland saline areas. Each land area should have its own strategy for land use and soil management, based on scientific agriculture and precision farming. It is necessary to take up this task on a massive scale. However, farmers cannot afford to invest in such waste land.

A rough estimate of the cost of developing one hectare of land is about INR 2,00,000/- to INR 2,50,000/-. It is, therefore, necessary to bring in public private partnership (PPP) to sustain such projects. It can create huge employment opportunities and go a long way in meeting food security challenge of hungry millions apart from creating vegetative cover which will absorb CO_2 from atmosphere and make soil fertile with right agronomic practices.

Lakhpat, Kutch District

May – 2006 ***August – 2006*** ***August – 2007***

Rain Water Harvesting Structures

Use of Wetland

- Wetland is an area of land, where soil is saturated with moisture, permanently or seasonally or covered by shallow water.
- Wetlands are useful for:
  - ✓ food source and resource recycling, Predominant occupation of two-third of working population for their livelihood residing in coastal areas.
  - ✓ Scientific research & Educational initiatives.
  - ✓ Recreational activities and Nature Services
  - ✓ In terms of products, they are source of fish crops, vegetable & rice crops, medicinal plants and other organic products.

East Kolkata Wetlands (EKW) through its bheries / fisheries caters to the food, sanitation and livelihood security of its nearly a lakh inhabitants by recycling 980 million ltrs of sewage per day with a detention period of

30 days. About 150 tonnes of vegetables, 10,500 tonnes of table fish per day in addition to nearly 11 mt tonnes of rice per year. This intricate link of eco system productivity based on recycling and livelihood has created a favourable market mechanism that rewards conservation initiatives. This is called Bio Rights Framework and is a model that can be suitably adapted in systems with comparable profiles of form and function. South Asian Forum for Environment (SAFE) led by Dr. Dipayn Dey has played catalyst role in this entire development.

East Kolkata Wetlands

Climate Smart Practices

Crop rotation, Inter cropping, Drip irrigation, Mix farming, Composting, Weather advisory, Animal husbandry including biogas & solar

By promoting legume as intercrop - Total Nitrogen fixed in soil is 103 MT equals to 224 MT of Urea

By promoting drip irrigation in 3684 Ha area, 10 Million Cubic meter (10% of total storage capacity in basin area) water is conserved.

By promoting drip irrigation through awareness campaigns improvement in irrigation effciency is achieved.

NCCSD

Use of Biotechnology for Climate Smart Agriculture(CSA)

Tissue culture,
Biotechnology tools,
Madhyam for composting,
Cow Urine (Gaumutra), Liquid fertilizers.

Composting: Farm and animal waste for soil improvement. This activity was carried out with about 750 farmers.

Use of cow urine for soil improvement:
30 farmers, 145 Ha land area

Tissue culture plantation:
67 Ha land area
(date palm)

Value Added Agriculture

Grading, Packing & Marketing, SHG activities, Direct marketing for mango & dates, Producer Company

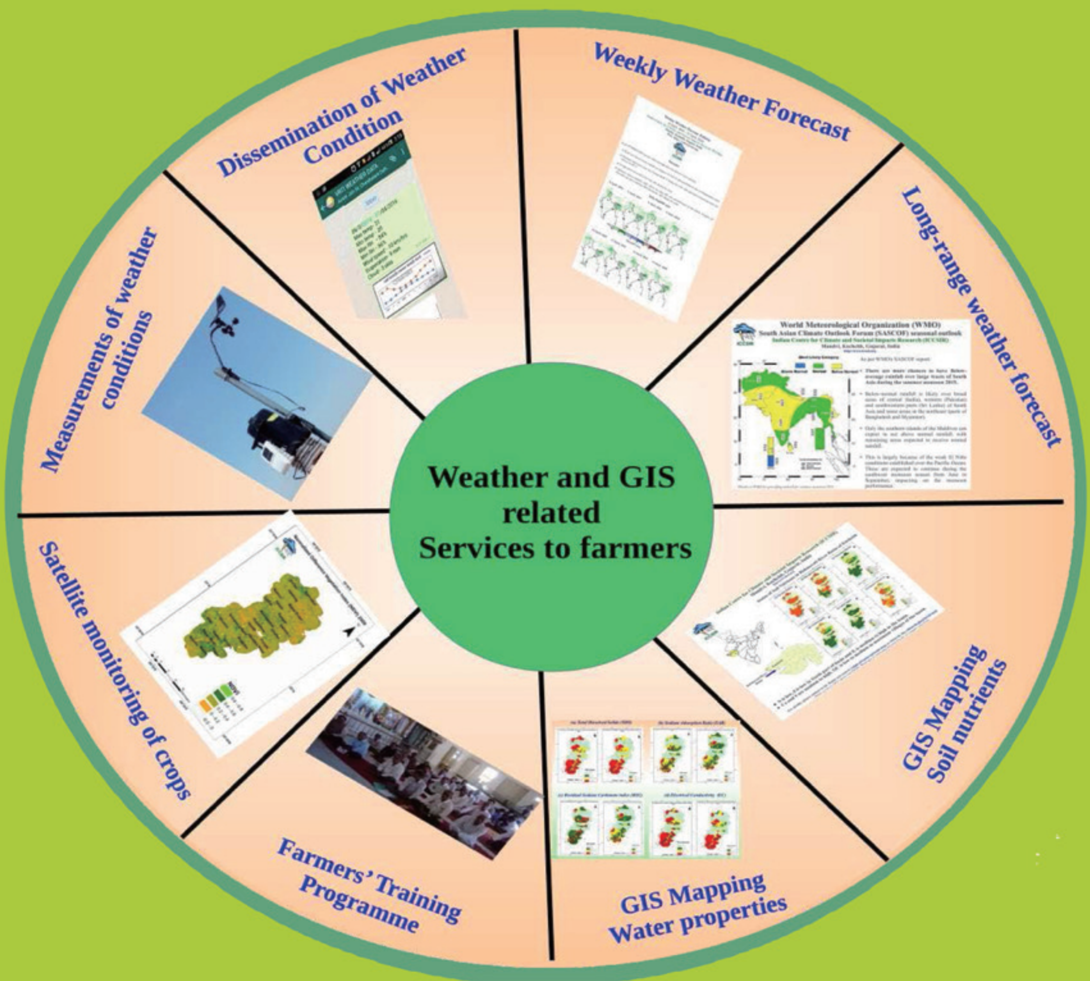
Women empowerment through micro finance activities: 68 Self Help Groups (SHGs) were formed and 840 women have initiated monthly saving and microfinance related activities. Till date saving of these women is around 1.5 million INR (Indian Rupees). This activity has developed leadership skills and social status upliftment for women.

Grading, packing & marketing of agriculture produce by SHGs: 240 MT

Mango marketing to end user: 60 MT

NCCSD

Weather and GIS Related Services to Farmers

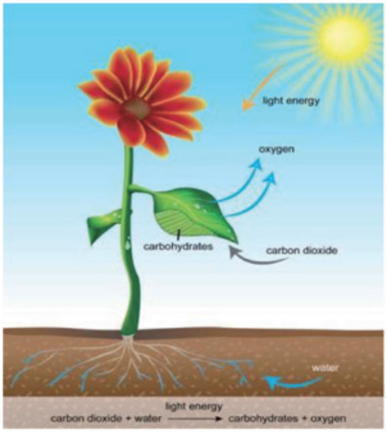


Integrated River Basin Management (IRBM)

Burning Issue for the Earth: Climate change and major culprit of it is increasing CO_2 in the atmosphere.

Solution for Mitigating Climate Change: Promoting PHOTOSYNTHESIS to consume CO_2

Landscape Approach for promoting photosynthesis: INTEGRATED RIVER BASIN MANAGEMENT



Farms, forests, water bodies and settlement are not isolated elements, but part of a wider landscape in which all land uses are integrated. A landscape approach entails viewing and managing multiple land uses in an integrated manner, considering both the natural environment and the human systems that depend on it.

IRBM is the process of coordinating conservation, management and development of water, land and related resources within the river basin, in order to maximize economic and social benefit while preserving and where necessary restoring freshwater ecosystems.

Better Soil & Water Management ▼ **More Vegetation & Green Cover** ▼ **More Photosynthesis** ▼ **CO_2 fixation**

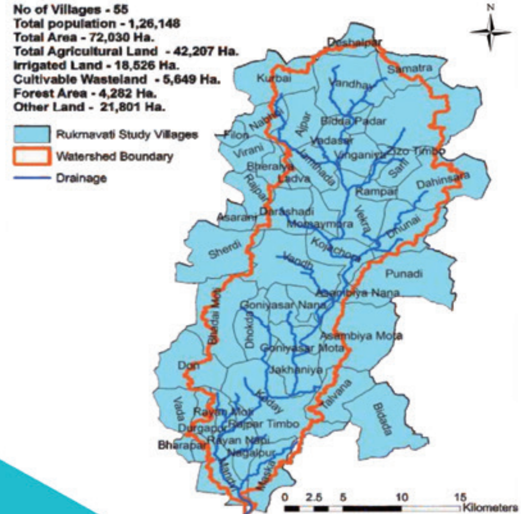
Soil Health Management ▼ **Promoting Waste Recycling for Composting** ▼ **Better Animal Waste Management** ▼ **Less Methane Generation**

Mitigation leads to Positive Impact on Climate change

NCCSD

Rukmavati River Basin

Casestudy from Kutch, Gujarat



Water Resource Management (Hydrology):

New check dams – 107, Storage capacity - 40 Million Cubic Feet, Beneficial farmers – 1692, Area under irrigation - 3784 hectares

Desilting in 84 structures and 504 hectares benefitting 379 farmers resulted in reduced requirement of chemical fertilizer.

50% saving in water through promotion of drip irrigation in 3684 Ha area.

Natural Resource Management

2000 MT waste converted to compost from 400 Ha of area by 750 farmers resulted in improvement in soil fertility

Promoting legume as inter crop – nitrogen fixation in soil and also providing food security (Nitrogen fixation - 103 MT in 3600 Ha (224 MT urea saving)

Animal husbandry

Pasture land development in 500 Ha of land to provide fodder security.

Farm bunding to conserve soil moisture and control soil erosion, in 64 hectares of land resulted in improvement of productivity by 8 – 10%.

Improving market linkage, 20% increase in income

Tree plantation

35,000 trees planted in basin area to improve greenery

Horticultural plantation of Date palm, Pomegranate, Mango, Ber, Banana and Papaya in 500 Ha to provide income to farmers.

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Seaweed cultivation for 'Climate Change Mitigation'

- Increased carbon dioxide in the atmosphere is responsible for rapid climate change
- The ocean provides unlimited space for capturing solar energy by different marine plants through photosynthesis, Seaweed cultivation is one such option
- Seaweed is important not only as part of the marine ecosystem, but also as sources of foods, nutrients and other natural products
- India has a coastal line of around 7,500 km and potential seaweed farming zones can be identified along the coastal states
- Seaweed farming can be considered as a supplementary income source of livelihoods for coastal community including fisherfolks
- Carbon sequestration through seaweed farming. From 1 ton red seaweed (Eucheuma seaweed), the sequestered CO_2 = 1.4 ton/Yr. About 4 ton of wet seaweed can grow in one hectare (ha) area.

NCCSD

Seaweed cultivation for 'Climate Change Mitigation'

The Concept:

The project aims at establishing & demonstrating following components:

- Seaweed farming unit in coastal area of Kachchh which will serve as raw material source for biomethane generation
- A model power generation unit utilizing biomethane produced though seaweed fed biodigester
- A composting unit producing liquid fertilizer and solid compost from slurry obtained as left over material from biodigester

Project Rationale:

- The seaweed cultivation has potential to provide triple win situation by providing employment opportunities, clean power and higher agricultural production through its use as compost
- It can be developed as a successful cottage or co-operative sector industry. Gujarat has good potential for seaweed farming as it has longest seacoast in India

NCCSD

"ZERO TILL" Conservation Agriculture Technique for RICE & Rice based Crops.

TRADITIONAL	ZERO-TILL
Yields are Low	Higher Yields
Loss of fertile Soil	Earthworms colonies formed sustaining soil ecosystem
Flooding	Top fertile soil retained
Drudgery, expensive, time consuming	No Drudgery
Transplantation Tillage	Direct Seeding
Nursery	Permanent raised beds

NCCSD

Farmer to Farmer Project
Building Climate Smart Farmers

Climate Change and Farmers:

The continuing and increasing adverse weather events all are affecting farmers across the world. While Global Warming is International Phenomena- its adverse impact is at village level on Farm Land- most often farmers finds his only source of Income depleting – by crop failure or low productivity. There is high need to have transfer of technologies - expertise from developed nation. NCCSD is working for this with Florida Agricultural and Mechanical university, USA.

Developing Climate Smart Farmers:

Vision - In the arena of changing climate, develop a one-stop Center to serve local, regional, national, and global farmers, and provide them with solutions for different climate-resilient agricultural practices

Mission - The Mission of the Center is to build the capacity of farmers on the subject of climate resilient agriculture through hands-on training, which will help them not only sustain farm productivity under adverse climatic conditions, but to increase productivity, and thus profitability.

Objectives:

- Strengthen the portfolio of agricultural technologies at that would help improve the productivity and products that fetch better market price.
- Develop a Non formal Education Center, in its role as a non formal education and outreach facility for extending climate smart agriculture to farmers across the state of Gujarat and India and GACSA.
- Address members and transfer suitable bio technology for value addition in existing crops.
- Develop Good Agricultural Practices for better price in market.
- Identify local level processing of agri-commodities to generate wealth in rural areas and provide entrepreneur opportunity to rural youth and prepare them to work on building own business plan.
- To prepare farmers to build own book keeping system to constantly analyze which crop they will gain the most.
- To develop and orient new farmers - Women farmers
- In short project aim to
  "Promote sustainable livelihood and
  contribute to food security for hungry millions

Farmer to Farmer Project
Building Climate Smart Farmers

Strategic partners - convergence of efforts for global technology transfer through Public – Private Partnership

- Florida Agriculture & Mechanical University (FAMU), Florida – USA with USAID - Govt. of USA
- National Council for Climate Change & Sustainable Development
- Vivekanand Research & Training Institute - Mandvi, Kutch
- Anand Agriculture University
- Junagadh Agriculture University
- Agriculture Technology Management Agency, Government of Gujarat, Government of India

Project highlight:

- No. of FAMU experts completed training assignments – 13
- Total no. of trainees – 4,654 from 13 Districts of Gujarat

  Male trainees: 3,370

  Female trainees: 1,284
- Training of Trainers were also conducted to continue this project
- Training modules of the subjects covered by FAMU volunteers have been developed in local language

Farmer to Farmer Project
Building Climate Smart Farmers

Major recommendation adopted by farmers:

- Proper manure management and application of organic matter in soil
- Rain water harvesting and water management
- Involving women farmer in farm decision making
- Post harvest management in different crops

The next phase:

Strengthening the Project:

VRTI has set up :

- Permanent" Non Formal Education Center" – under banner of this center about 350 farmers have been trained for by local trainers
- Soil and Water Test Lab.
- Demonstration- Model Farm.
- Identified and developed 50 farmers who have setup model farm in their villages
- Guidebook in local language for farmers is in developing phase
- Guidebook in English (under prepration)
- Video Documentary with illustrations of success stories (under prepration)

PROF. SWAMINATHAN APPROACH CLIMATE RESILIENT AGRICULTURE – RAJASTHAN & ANDHRA PRADESH

Prof. M S Swaminathan, the veteran scientist has set up Swaminathan Research Foundation which is working on climate resilient agriculture on many part of our country. Dr. R R Nambi, Director of the Institute describes his all inclusive approach as under for its projects in Rajasthan and Andhra Pradesh.

Catalytic Interventions

- Design of cropping system based on appropriate
- Promotion of locally suitable best practices

Establishment of village level Agro-Meteorology Observatories

- Training of 'Climate Risk Managers'
- Training of Panchayat leaders / Village Sarpanchs
- Development of a training module for Extension Agents in collaboration with MANAGE, Hyderabad
- Awareness
- Strengthening of village institutions

Land use based interventions

- Control of erosion losses –sloppy land treatment
- Crop advisory based on weather forecast
- Development of cropping systems based on weather codes
- Testing of option sets (SRI, mixed cropping, varietal trials)
- Treatment of alkaline soils
- Kitchen gardens for nutrition

Hypothesis – Land Use: Updated village level and use maps and option sets for rainfall scenarios (drought, normal, excessive) provide information for appropriate agronomic practices to stabilize yield from rain fed farming; greater food and / or economic security.

Activity	Output	Outcome
Best practice - System Rice Intensification (SRI)	• 30% Reduction in water usage as compared to conventional method • 20% Increased productivity	• 52 Rice farmers (60 acres) adopted SRI against 150 rice growers
	Output Indicator	**Outcome Indicator**
	• Quantity of water used for crop duration • No. of productive tillers/ hill, no. of grains/ panicle and test weight	• No. of acres and farmers under SRI

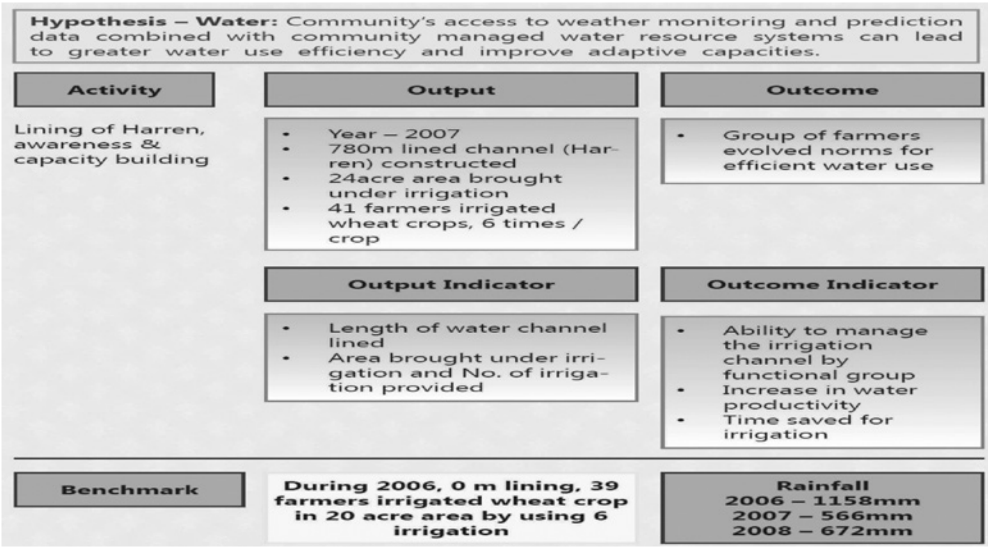
Benchmark: Conventional submergence rice was practices

Water based interventions

- Lining of irrigation channels
- Reduction of irrigation intensity
- Groundwater monitoring
- Strengthening water harvesting structures /revival and restoration of traditional/community based water conservation measures
- Revival of traditional barren system
- Formation and revitalization of water user







Mangrove Conservation

Started in Tamil Nadu in 1996

Extended to all the major mangroves of the east coast of India

Tamil Nadu	: 2 Sites
Andhra Pradesh	: 2 Sites
Orissa	: 2 Sites
West Bengal	: 1 site

Before restoration of Mangroves - 1998

Development of Restoration Method :

Pichavaram, Tamil Nadu, India

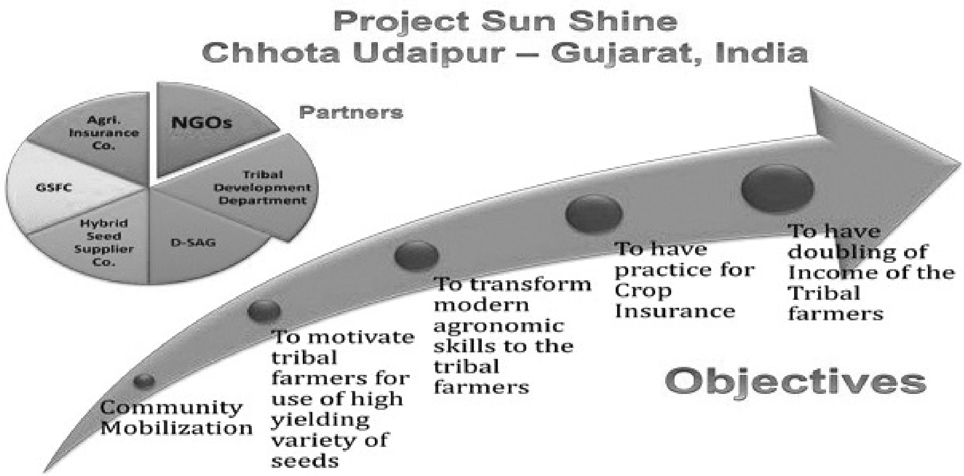
- Reserve Forest in 1897; managed by Forest Department - British and Indian
- Working plans available since 1897; degradation started 1930s
- Attempts to restore them could not yield much result
- Started working on restoration in 1993 - 55% degraded

After restoration of Mangroves - 2004

Source: Book on Leadership and Greener Agriculture in the Arena of Climate Change

THE USE OF TECHNOLOGY FOR CLIMATE SMART AGRICULTURE

Chhota Udaipur – A remote tribal district in Gujarat, India



Shroff Foundation Trust, Led by Ms Shruti Shroff

Promoted series of initiative for increasing income of Farmers by following strategy.

Maize Crop

Year wise Coverage		2009-10	2010-11	2011-12
Blocks		Chhotaudepur	Chhotaudepur & Jetpur Pavi	Chhotaudepur & Jetpur Pavi
No. of Villages		141	352	352
Allotted Targets		14000	29500	39000
No. of Farmers Registered		11000 (79%)	16550 (56%)	35449 (91%)
No. of Farmers - Distributed Material		11000 (79%)	16550 (56%)	34953 (90 %)
Collected Community Contribution		Rs. 55 lacks	Rs. 151.42 lacks	Rs. 311.18 lacks
Seeds Distributed		110 MT	132.4 MT	279.624 MT
Fertilizer Distributed	UREA	550 MT	827.5 MT	1747.65 MT
	DAP	550 MT	827.5 MT	1747.65 MT
	MOP	550 MT	827.5 MT	1747.65 MT

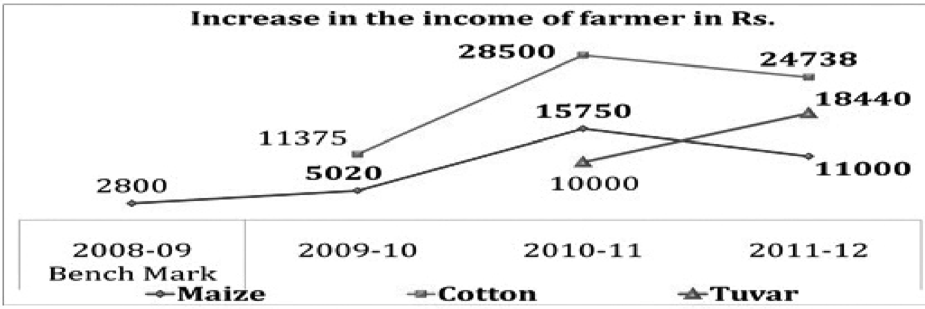
Cotton Crop

Year wise Coverage		2010-11	2011-12
Blocks		Chhotaudepur & Jetpur Pavi	
No. of Villages		352	352
Allotted Targets		2000	3500
No. of Farmers Benefited		2000	3500
Collected Community Contribution		Rs. 22 lacks	Rs. 52.5 lacks
Seeds Distributed		1.8 MT	3.15 MT
Fertilizer Distributed	UREA	300 MT	525 MT
	DAP	100 MT	175 MT
	MOP	100 MT	175 MT

Tuvar Crop

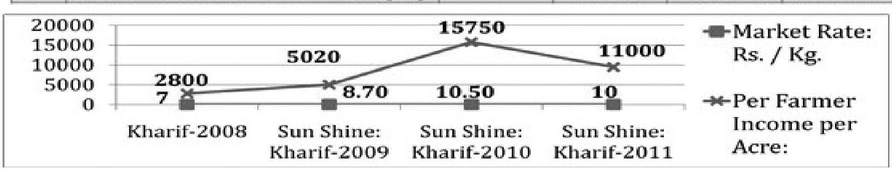
Year wise Coverage		2011-12
Blocks		Chhotaudepur & Jetpur Pavi
No. of Villages		352
Allotted Targets		3500
No. of Farmers Benefited		3500
Collected Community Contribution		Rs. 52.5 lacks
Seeds Distributed		3.15 MT
Fertilizer Distributed	DAP	175 MT

Crop wise increase in the income of farmers



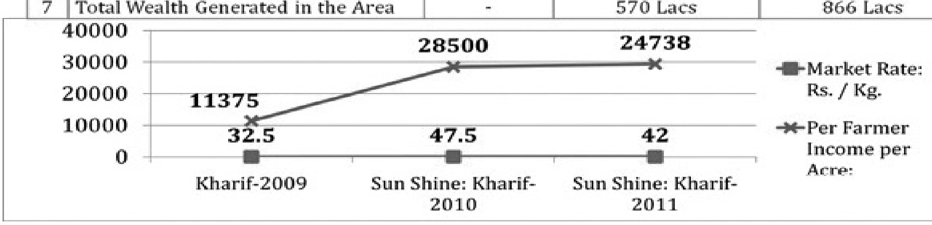
MAIZE Crop – Yield details

Sr.	Details	2008-09 Bench Mark	2009-10 Kharif	2010-11 Kharif	2011-12 Kharif
1	Covered Farmers	1	11000	16550	34953
2	Contribution Collected Rs.	-	55 Lacs	151 Lacs	306 Lacs
3	Approximate Input Cost Rs.	-	216 Lacs	333 Lacs	714 Lacs
4	Average Yield - Quintal per Acre	4	5.77	15	11
5	Market Rate Rs. / Kg.	7	8.7	10.5	10
6	Income received per farmer	2,800	5,020	15,750	11,000
7	Total Wealth Generated in the Area (Rs.)	-	552 Lacs	2606 Lacs	3845 Lacs



Cotton Crop – Yield details

Sr.	Details	2009-10 Bench Mark	Project Sun Shine - B. T. Cotton	
			2010-11 Kharif	2011-12 Kharif
1	Covered Farmers	1	2000	3500
2	Contribution Collected Rs.	-	22 Lacs	52.50 Lacs
3	Approximate Input Cost Rs.	-	70.76 Lacs	124 Lacs
4	Average Yield - Quintal per Acre	3.5	6	5.89
5	Market Rate Rs. / Kg.	32.5	47.5	42
6	Income received per farmer	11,375	28,500	24,738
7	Total Wealth Generated in the Area	-	570 Lacs	866 Lacs



Vanbandhu Kalyan Yojana

Farmers Success Stories

1. **Rathava Keriben Ganiyabhai**

- Age: 55
- Occupation: Agriculture
- BPL No: VACHHJ00500140
- Contribution: Rs. 500/-
- Received inputs: Maize-8 kg.- 2 bags, D.A.P-50 kg.-1 bag, Urea-50 kg.-1 bag, Potash- 50 kg.- 1 bag
- Village: Judavant, Taluka: Chhota-Udepur, District: Baroda

Says Smt. Keriben, We used hybrid seed of maize in all seasons & received double income. I was able to grow 1.4 tons (14 Kwintal) of the maize from this kit.

2. **Rathava Rudiyabhai Raysingbhai**

- Age: 46
- Occupation: Agriculture
- BPL No: VACHHJ00500068
- Contribution: Rs. 500/-
- Received inputs: Maize-8 kg.- 2 bags, D.A.P-50 kg.-1 bag, Urea-50 kg.-1 bag, Potash- 50 kg.- 1 bag
- Village: Judavant, Taluka: Chhota-Udepur, District: Baroda

Says Shri Rudiyabhai, We used hybrid seed of maize in all seasons & received double income. I was able to grow 1.3 tons (13 Kwintal) of the maize from this kit.

3. **Rathava Karanbhai Chimabhai**

- Age: 51
- Occupation: Agriculture
- BPL No: VACHHS00100064
- Contribution: Rs. 1500/-
- Received inputs: B T Cotton-950 grams-2 bags, D.A.P-50 kg.-1 bag,

Urea-150 kg.-3 bags, Potash- 50 kg.- 1 bag, Lansargold-500 grams, Monocrotophos-500 ML, Saf-350 grams, Aishwarya Gold-250 ML

- Village: Jhoj, Taluka: Chhota-Udepur, District: Baroda

Says Shri Karanbhai, We used hybrid seed of Cotton in two seasons & received good price in the market. I was able to grow 0.7 tons (7 Kwintal) of the Cotton from received kit.

4. Rathava Sukhabhai Mochidabhai

- Age: 60
- Occupation: Agriculture
- BPL No: VAJETS00500001
- Contribution: Rs. 1100/-
- Received inputs: B T Cotton-950 grams-2 bags, D.A.P-50 kg.-1 bag, Urea-150 kg.-3 bags, Potash- 50 kg.- 1 bag, Lansargold-500 grams, Monocrotophos-500 ML, Saf-350 grams, Aishwarya Gold-250 ML
- Village: Sajod, Post: Motibej, Taluka: Pavi-Jetpur, District: Baroda

Says Shri Sukhabhai, I was able to grow 10 Kwintal in a acre of the Cotton from received kit.

5. Rathava Motesinghbhai Bhanatabhai

- Age: 45
- Occupation: Agriculture
- BPL No: VAJETG0100066
- Beneficiary's contribution: Rs. 2500/-
- Received inputs: Banana tissue-culture plantlets -1370 Nos. of plants, D.A.P-200 kgs.-4 bag, Urea-650 kgs.-13 bags, Potash-900 kgs.- 18 bag, Lansargold-500 grams, Monocrotophos-500 ML, Saf-350 grams, Aishwarya Gold-250 ML

- Village: Ghutanvad, Post: Ghutiya, Taluka: Pavi- Jetpur, District: Baroda

Says Shri Motesinghbhai, I am able to earn Rs. 110000/- in a acre . Produce 22 to 27 kg. of every bunches of bananas because of this kit.

Shroff Foundation Trust led by Smt. Sruti Shroff to converge a massive Government programme of Van Bandhu - "Forest Brother" - into a technology driven with use hybrid and BT seeds and farm practices which were technology driven to multiply income of poor tribal farmers.

6. **Use of Balanced Fertilizer based on Soil Health Analysis – the case study of Jambusar, Bharuch, Gujarat**

   Maheshbhai Sindha, Piludra of Jambusar Taluka of Bharuch district owns three acres of land. Before he became aware about new agricultural products, he was using intensive chemical fertilizer and plant seeds which were available at cheaper cost. His main crop was cotton but the expenses were high and the yield was low. After having his land examined for Soil Health Analysis in 2012 and 13 he started using certified seeds and balanced doze of fertilizer both organic and in organic-chemical as per recommendation. This reduced his cost in agricultural operations by Rs.2,800 and increased productivity in cotton by 4 quintal. He learned about vermin-compost and started using crop residue along with worms to develop compost fertilizer. This increased productivity further by one quintal and simultaneously, he started selling worms to other farmers to make their compost. Within two years, his income increased to Rs.31,500/-.

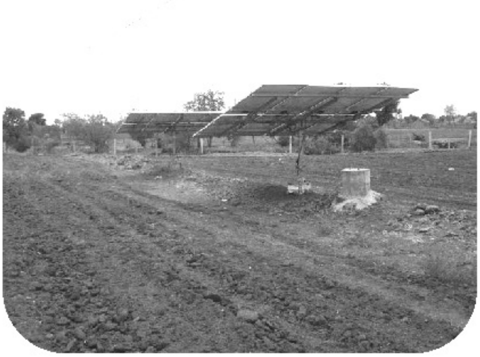
ENERGY SAVING AND CLIMATE CHANGE

		CSA objectives		
		Sustainable increases in productivity and income	**Strengthened resilience to climate change and variability**	**Agriculture's reduced impact on climate change**
Energy-smart food objectives	Increased energy efficiency	**General:** Savings on energy costs (after upfront costs for technology have been paid) will result in increased profit if productivity is not excessively decreased **Specific:** Practices such as replacement of synthetic fertilizers with application of agricultural residues or manure, which require fewer external inputs and increase yields, can contribute to both increased energy efficiency and sustainable increases in productivity and income. Practices that reduce external energy inputs and (at least) maintain yields, such as reduced or zero tillage, will increase energy efficiency and sustainably increase income. If such practices are combined with others that increase yields (such as nitrogenfixing cover crops or manure trees), this can contribute to both energy efficiency and sustainable increases in productivity and income. There is also much scope for enhanced post-harvest technologies and practices that contribute to both energy efficiency and sustainable increases in productivity and income, such as improved crop and food storage, packaging and distribution.	**General:** Savings in energy costs will result in increased income available to enhance adaptive capacity. Decreased dependence on energy inputs (especially fossil fuels) will tend to reduce vulnerability to shocks in energy prices Some "climate-proof" agricultural production and energy systems may result in lower energy efficiency **Specific:** Practices such as conservation agriculture that enhance crop cover, soil water retention and soil organic matter may increase resilience to drought and extreme weather events Drip irrigation tends to enhance resilience and may increase energy efficiency through its impacts on productivity – compared flow irrigation through by direct pumping.	**General:** Improvements in energy efficiency, whether due to lower embedded energy in inputs or on-farm fuel combustion, will reduce GHG emissions in the production chain **Specific:** Practices such as reduced or zero tillage, precision agriculture, replacement of synthetic fertilizers with agricultural residues or manure, elimination of pesticides through integrated pest management or enhanced distribution logistics that reduce fossil fuel combustion will generally lead to reduced GHG emissions. Reduced or zero tillage, in combination with permanent crop cover, crop rotation and elimination of agrochemicals may also sequester carbon.

Source: Bogdanski *et al.*, 2010; Bogdanski, 2012 - Climate Smart Agriculture Source Book, FAO 2013

Solar Water Pump – Bhavnagar

A farmer of Sartanpar village, about 25 km from Bhavnagar has installed solar water pump having 7.5 HP capacity. It pumps out water from about 400 ft deep bore-well. It runs about 8 to 10 hrs a day when sky is clear and sun-shine is good enough. Although, presently initial cost is high, that is around Rs 8 lakh for installing 7.5 HP pump but 'Running Cost' is zero!!!. A farmer has to keep solar panels clean to maintain maximum efficiency. That is all. In very near future, hopefully, cost of solar panel may come down and government provides subsidy for such unit, some farmers will definitely get the benefit of this clean technology. Well, presently, electricity (conventional) for agriculture is greatly subsidized by the government, just has to shift it and promote generation of this clean energy which is abundant!!!



Micro irrigation system

Solar Panels – for irrigation and Electricity for Income

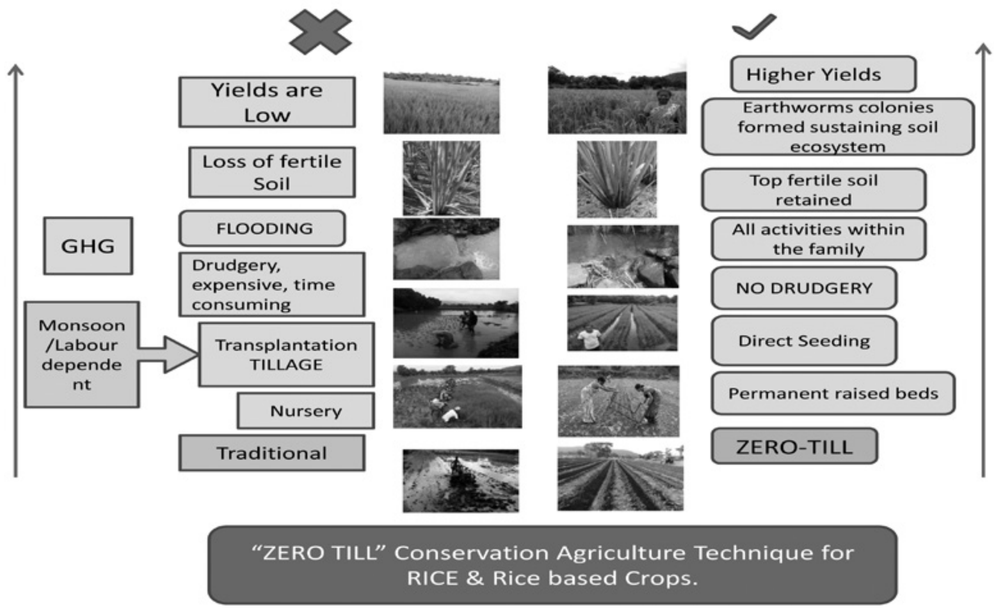
- This is an innovative project:-Evening and night to use solar energy in Dhundi village of Anand district –Gujarat by Setting up Dhundi Solar Pump Irrigation Cooperative.
- Install solar pumps for pumping of water.
- Use solar panels for producing electricity.-when not in use for water pumping
- When pump is not used, panels are linked with local electrical greed and farmers are paid for the electricity produced-This provides assured income throughout the year

RESOURCE CONSERVING TECHNOLOGIES

POTENTIAL BENEFITS OF THE KEY RESOURCE CONSERVING TECHNOLOGIES (RCTS) IN TERMS OF CLIMATE CHANGE ADAPTATION RELATIVE TO CONVENTIONAL PRACTICES

RCT	Potential benefits relative to conventional practices
Zero tillage	Reduced water use, C sequestration, increases yield and income, reduced fuel consumption, reduced GHG emission, more tolerant to heat stress
Land leveling	Reduced water use, reduced fuel consumption, reduced GHG emissions, increased area for cultivation
Direct drill seeding of rice	Less requirement of water, time saving, better post-harvest condition of field, deeper root growth, more tolerance to water and heat stress, reduced methane emission
Diversification	Efficient use of water, increased income, increased nutritional security, conserve soil fertility, reduced risk
Raised bed planting	Less water use, improved drainage, better residue management, less lodging of crop, more tolerant to water stress
Leaf colour chart for N management, nitrification inhibitors	Reduces fertilizer N requirement, reduced N loss and environmental pollution, reduced nitrous oxide emission
Crop residue management	Moderates soil temperature, improves soil quality, reduces soil erosion, reduces evaporation losses and conserves soil moisture, increases C sequestration, avoids burning and reduces environment pollution, increases tolerance to heat stress, reduces weed infestation.
Sprinkler/drip irrigation	Increases water and nutrient use efficiency, reduces GHG emissions

Source : Dr. J.C. Dagar, Formerly ADG (ICAR)


Yields are Low
Loss of fertile Soil
FLOODING
Drudgery, expensive, time consuming
GHG
Monsoon /Labour dependent
Transplantation TILLAGE
Nursery
Traditional
Higher Yields
Earthworms colonies formed sustaining soil ecosystem
Top fertile soil retained
All activities within the family
NO DRUDGERY
Direct Seeding
Permanent raised beds
ZERO-TILL
"ZERO TILL" Conservation Agriculture Technique for RICE & Rice based Crops.


"ZERO TILL" Conservation Agriculture Technique for RICE & Rice based Crops.
Shalini says, it is easy , simple, saves Money & Time.
HAPPY FARMERS

ADAPTATION MEASURES

❖ **Crop Diversification**

Cropping system	Total variable cost (Rs/ha/yr)	Net returns (Rs/ha/yr)	WUE (Kg/m^3)	Electric consumption
Maize-potato-onion	**83,383**	**1,25,023**	**130**	**1,205**
Groundnut-potato-bajra	**62,435**	**1,11,839**	**103**	**955**
Maize-potato-moong	**64,250**	**78,588**	**105**	**93**
Maize-wheat-moong	**48,255**	**72,797**	**92**	**853**
Rice-wheat	**39,318**	**59,742**	**212**	**1,963**

Replacement of 5% area under Rice-wheat system (2.6 million ha) by alternative crops will save 1.3 lakh ha-m irrigation water with additional net returns of Rs. 465 crores besides 162 million electric units thus contributing a lot in reducing GHGs

❖ **System of Rice Intensification (SRI)**

- Practiced in southern states like Tamil Nadu, Andhra Pradesh, Karnataka and in few Eastern states like Tripura and Assam

  Benefits of SRI

  Water saving : 60- 70 cm vs. 120 –150 cm in conventional

  Enhanced yield : Additional yield 500 to 1500 kg / ha

  Less seed rate : 5-8 kg/ha vs. 60 kg ha^{-1} – short duration

  Labour saving : 12 vs. 30 labours in conventional nursery

Source : Dr. J.C. Dagar, Formerly ADG (ICAR)

❖ Benefits of Bed Planting Observed in India

Crops	Water saving (% over flat)	Yield increase (% over flat)	Raised bed planting in wheat
Maize	35.5	37.4	
Urd Bean	26.9	33.6	
Green peas	32.4	14.5	
Wheat	26.3	6.4	
Rice	42.0	6.2	
Okra	33.3	18.2	
Carrot	31.8	26.9	
Pigeonpea	30.0	46.7	
Gram	27.3	17.1	
Source: Connor et al. (2003)			

Source : Dr. J.C. Dagar, Formerly ADG (ICAR)

NATIONAL INITIATIVE ON CLIMATE RESILIENT AGRICULTURE (NICRA)/ CRIDA

- Launched in January, 2011 with an outlay of Rs. 350 crores for 2010-12.
- Strategic research, technology demonstrations, capacity building and sponsored research are the components
- Targets- Field crops, horticulture and plantation crops, livestock and fisheries
- Demonstration of available climate resilient technologies at farmers' field in 100 most vulnerable districts of 27 states and one UT (A&N)
- One hundred thousand farmers to be benefited directly with the on-farm demonstrations of the technology

❖ **Coping with Floods – upscaling NICRA experience in Assam**

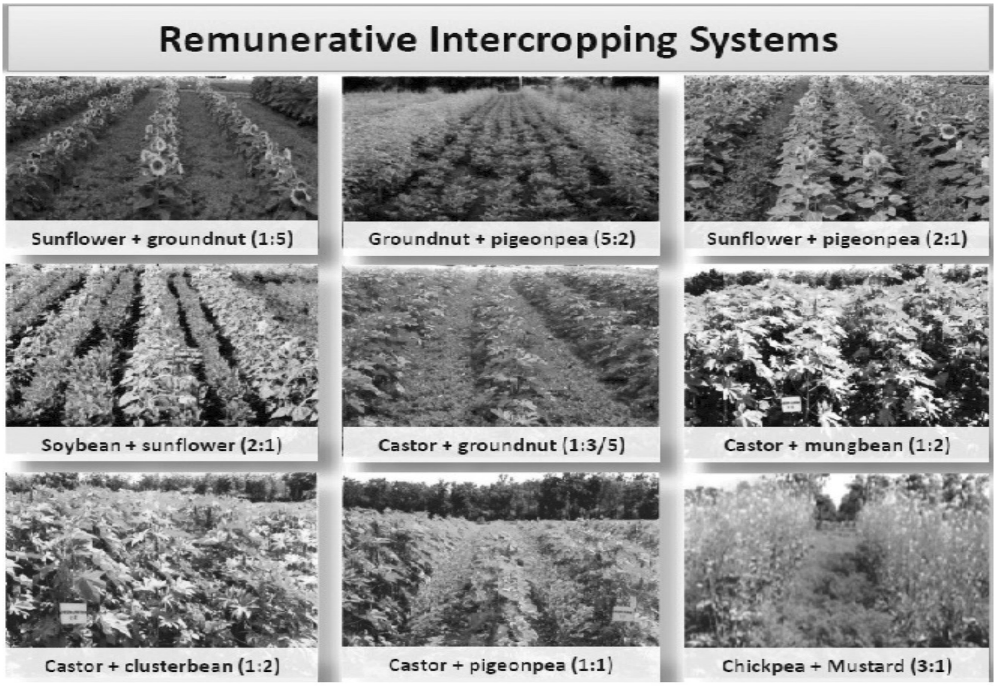
Saturation of whole villages of Ganakdoloni near Biswanath Chariali in Assam

with Jalashree in Sali Rice and salvaging the crop during 2012 floods caught the attention of CRIDA and a scheme was planned to map the flood prone villages and promote the intervention in 75,000 ha of land.

Source: Climate Resilience in Agriculture – Where are we ? by Dr. Arunachalam, ICAR

Mixed Cropping is growing a variety of crops and plants together.

Mixed cropping imitates nature and does not allow domination by particular pest. It helps maintain a dynamic control on pests by promoting natural enemies, that is – predators and parasites of pests simultaneously.	On the other hand a lesser diversity of plants may attract only a few predators and parasites. This may allow the populations of plant eating insects grow significantly.
Some examples of successful mixed cropping in Gujarat are: Sesame with cotton and other pulses Maize with Drilled rice crop Pigeon Pea with Drilled rice crop Maize with Soya bean.	Intercropping is a form of mixed cropping. For example, plant corn in one row and beans in the next reduces the chances of any single pest taking over the field. Additionally, intercropping controls weeds because weeds cannot find enough space to grow and spread. It also keeps the soil healthy through a wide variety of nutrients that are released by the plants into the soils.



Castor – A stress resistant crop

Castor adapts well in drought prone areas due to its deep root system. It can also be grown in shallow soils on rocks. Although It is cultivated as rainfed crop in drought prone areas where annual rainfall is between 380 to 500 mm, it can also be taken as profitable second or third crop in irrigated lands.

Gujarat being a drought prone state with uneven distribution of rainfall has led to several crop failures. Castor being a no failure crop has become the future crop for this state and is grown on average 6.60 Lakh Hectares since last five years.

Farmers are provided with capacity building trainings under Public – Private Partnership by JAOL, Kalyan Foundation, NCCSD with State Agri. Extension team. The focus is to make farmers understand the physiology of castor, good agronomical practices involved in profitable castor cultivation and make them aware and understand changes in weather conditions and take adaptive measures.

Castor crop has proved to be a boon for the farmers and because of following reasons it is recommended as a sustainable crop to assure livelihood to farmers:

- Castor crop is a climate resilient and drought &salinity resistant crop.
- It can be grown throughout the year on all type of well drained soils.
- It requires almost 24% lesser Irrigation water as compared to other food grain crops.
- It is a long duration – wide spaced crop, which facilitates intercrop cultivation of short duration Kharif crops like pulses.
- Castor is hardy & have longer shelf life hence once harvested the produced castor beans can be stored in house for longer duration and easily transported to market with minimum losses.
- It provides handsome revenues with minimum expenditures on cropping practices, fertilizers & plant protection.
- Castor is having higher benefit to variable cost ration of 1:2.51 as compared to other crops viz., SummerBajara(1:2.36), Cotton (1:1.92), Fodder Maize (1:1.8), Fodder Sorghum (1:1.69).
- The crop used to provide revenue of Rs. 13,000 to Rs. 22,500 per Hectare in 2000 with average yield of 1186 Kg/Ha & Market price of Rs 11 – 19 / Kg; now in 2017 it generates Rs 64,700 to Rs. 1,00,300 per Hectare with average yield of 2090 Kg/Ha & Market price of Rs. 31 – 48/Kg.

SUGGESTION FOR MIXED FARMING SYSTEMS

	Management objective	Practices/technologies	Impact on food security	Effectiveness as an adaptation strategy	Effectiveness as an mitigation strategy	Main constraints to adoption
Crop and grazing land management	Crop residue management	No-till/minimum tillage; cover cropping; mulching	+++	+++	++	Competing demands for crop residue biomass
	Nutrient management	Composting; appropriate fertilizer and manure use; precision farming	+++	++	++	Cost, limited access to technology and information
	Soil management	Crop rotations, fallowing (green manures),intercropping with leguminous plants, conservation tillage	+++	+++	++	Minimal gains over short term (e.g. short term decreases in production due to reduced cropping intensity)
	Grazing management	Adjust stocking densities to feed availability	+++	+++	+++	Risk aversion of farmers
		Rotational grazing	++	+++	+++	
Water management	Water use efficiency and management	Supplemental irrigation/water harvesting	++	++		Requires investment in infrastructure, extension, capacity building
		Irrigation techniques to maximize water use (amount, timing, technology)	++	++		
		Modification of cropping calendar	++	++		Lack of information on seasonal climatic forecast trends, scenarios

Livestock management	Improved feed Management for cattle	Improving feed quality: diet supplementation; improved grass species; low cost fodder conservation technologies (e.g. baling, silage)	+++	+++	+++	High costs
	Altering integration within the system	Adaption of original breeds; ratio of crop-livestock, crop-pasture	++	+++	++	Lack of information on seasonal climatic forecast trends, scenarios
	Livestock management	Improved breeds and species (e.g. heat-tolerant breeds)	++	++	++	Productivity trade-off: more heattolerant. livestock breeds generally. have lower levels of productivity
		Infrastructure adaptation measures (e.g. housing, shade)	++	+++	+	
	Manure management	Anaerobic digesters for biogas and ertilizer	+++	+++	+++	High investment costs
		Composting, improved manure handling and storage, (e.g. covering manure heaps) application techniques (e.g. rapid incorporation)	++	+	++	

Mitigation/adaptation potential: + = low; ++ = medium; and +++= high

Source: Adapted from FAO, 2009b; Smith *et al.,* 2008; World Bank, 2008

MANAGEMENT OF LIVESTOCK

Climate Smart Livestock Practices

Livestock contribute to food security and livelihood. It is no longer supplementary source of income. In fact it provides cash income on weekly basis based on how well the marketing infrastructure is laid out.

Historically for arid and semi arid areas are known as drought prone areas like Kutch district of Gujarat, every year government initiated cattle migration which was organized due to lack of drinking water.

But livestock are prone / sensitive to changes in climate :

I. Main Impacts

- Causes
  - Increased temperature
  - Shifts in rainfall distribution
  - Increased frequency of extreme weather conditions.
- Impact
  - Low productivity with increased heat stress
  - Quality and availability of feeds and fodder
  - Emergences livestock disease
  - Increased competence with other sector for water source results in exhaustion of water.
  - The grazing area – Gauchars – get minimum yield of grass, they become barren due to over use. Reduced water availability leads to increase in disease and even migration as cost of feed go up.

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by Dr. Mayur Vyas, formerly Managing Director, Sabarkantha Milk Producer Union

II. Adaptive Measures

- Grazing Areas

- The community has to reduce number of animals for free grassing depending on grass available

- Government has to set-up fodder depots and provide water – non availability same may require planned migration of cattle to forest area/ irrigated areas where feed is available. In Kutch, up to year 2000 systematic cattle migration was practice. But with water supply from Narmada Dam pipeline and with Fodder Bank/Fodder Depots, cattle migration is minimized.

- Early Warning System and Insurance

  Use of weather information can help to local administration plan grass depots and water supply within districts or work out a planned migration.

III. Cattle Insurance at present covers cattle death but cost of forced migration may have brought under insurance cover

- **Breed Selection**

  The cross breed animals – particularly from European – American breeds are very sensitive heat. It may, therefore, be necessary to focus on original cattle breeds which are climate resilient and can endure heat stress or have capacity for long travel. The original cattle breeds of Gujarat – Geer &Kankreji cows are suitable for this purpose.

- Promoting Community Bio-gas Plants

  Cow discharges "Methane" – it can be converted into slurry and developed as bio-gas plant – which provides gas for cooking and slurry can be converted into vermin compost which can be marketed. Case study, Chhota Udaipuir.

IV. Landless Animal Holders

They are most vulnerable – as they depend on community grassing areas which get depleted – will need special assistance.

V. Milch Animals – suggested measures:

Summer:

The summer is the period when temperature of atmosphere is very high which directly affects the reproductive health of milk animals, poultry and fishes. The energy of animal is spend to keep body temperature cool and hence they do not get the typical symptoms of coming in heat to do artificial insemination. The milk production reduces for buffaloes and slight increase of milk production for cows.

If summer-monsoon gets delayed or summer is followed by drought then milk animal health is severely affected which leads to consistently reduction in milk production.

During heat and cold wave the feed intake reduces considerably in poultry, which effects the growth of the birds and production of eggs. Birds' mortality also increases and disease resistance reduces.

During high temperature period growth of pond and marine fishes gets affected. The reproduction of fishes and disease resistance also reduces.

Monsoon:

Monsoon is good period to get green fodder which is available in plenty, farmers try to feed excessive green fodder which is not in balance of fat carbohydrate and protein hence it leads to reduction in fat in milk and also animals get frequently sick. If excessive rain leads to flood and also causes outbreak of diseases

Winter:

Winter is highly favourable to milk animal and particularly to buffalo. Milk production of buffalo increases where as milk production in cows slightly decreases. Winters are also the best period for fertility of milk animals. During extreme cold it is necessity to protect milk animals by keeping them in warmer place or covering them with warm covers.

Effect of climate change impacting Milk Animals, Poultry and Fisheries

With time human needs increase resulting in increased industrialisation and urbanisation which started producing green house gases harmful not only to humans but also hazardous to the eco systems. This has lead to increase in the earth's atmospheric temperature which has also gradually affected the milk animals .. Temperature and humidity have direct effect on milch animals. Milch animals get stressed as temperature and humidity start rising.

We will discuss how these affect the milk animals and how to identify the level of stress:

1) **Mild stress:** When the animal have Increase respiration rates panting, sweating, leaks body surface and drinks water frequently that means animal is under mild stress.

2) **Moderate Heat Stress:** During moderate heat stress animal will have perfuse sweating, rapid breathing and reduction in milk production

3) **Severe heat stress:** If animal is having open mouth breathing with panting, stop eating feed means that it is under severe heat stress.

EFFECT ON MILK PRODUCTION:

Milk production of cow and buffalo declines as the Temperature and Humidity index rises. 10 to 30 % decline in milk production can be seen for long exposure of milk animals to high temperature and humidity.

EFFECT ON FEED INTAKE:

As the temperature rises the feed intake of milk animal starts declining which leads to decline in milk production and also poor reproductive health.

EFFECT ON REPRODUCTIVITY HEALTH OF MILK ANIMALS;

Temperature affects the reproductive health of milk animals. It leads to decline in conception rate. Animal needs repeat service to conceive. Long exposure to heat will lead to high calf mortality and reduces weight gain. It will also lead to decline in milk production of next generation and delay in maturity of calf. Heat will reduce the sperm count in male.

EFFECT ON HEALTH AND DISEASES:

Rise in Temperature and Humidity Index will lead to reduced immunity and outbreak of infectious diseases.

PROTECTION AGAINST CLIMATE CHANGE

It is not in one's hand to prevent the changes in climate that are taking place but knowing that these changes will affect our milk production, Poultry and fisheries production which will affect our economy, one can prepare to protect the milk animals, Poultry and fisheries against the changes that are taking place by adopting the prevention as describe.

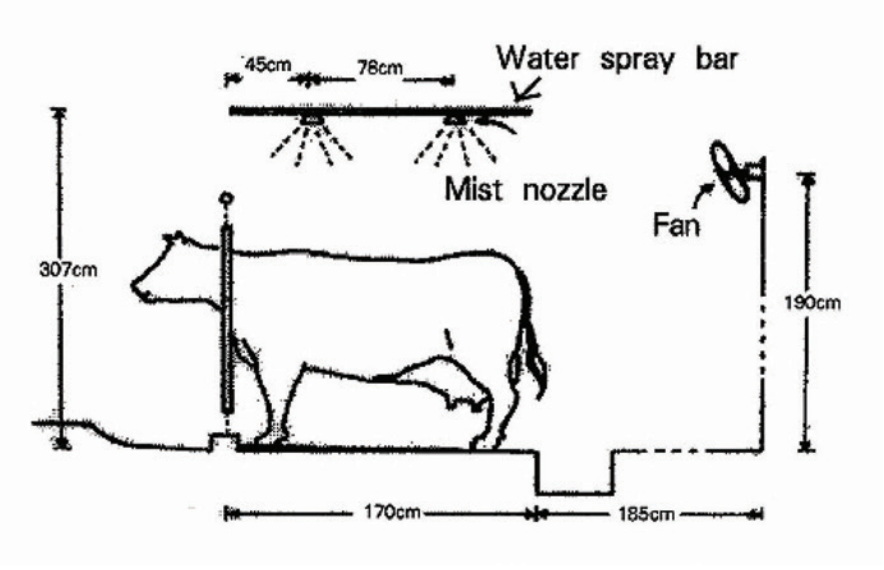
1) SELECTION OF MILK ANIMAL BREED:

In Gujarat we have two major climatic zones for milk animals. North Gujarat where climate is hot and dry and second is Saurashtra, Central and South Gujarat where climate is hot and humid. While selecting animals care must be taken that animal suitable for the zone must be selected i.e. if one wants to buy buffalo in Sabarkantha, then it must be from Mehsana or Palanpur and those in Saurashtra should buy Surati buffalo. Indigenous cow breed suitable for our weather is breed of cattle like Kankrej, Gir and others which sustain and yield well in adverse climate.

2) SHELTOR FOR MILK ANIMALS

The shelter for the milk animals is very important. If proper shelter is provided, one can eliminate 50% effect of climate changes. The shelter must have following features:

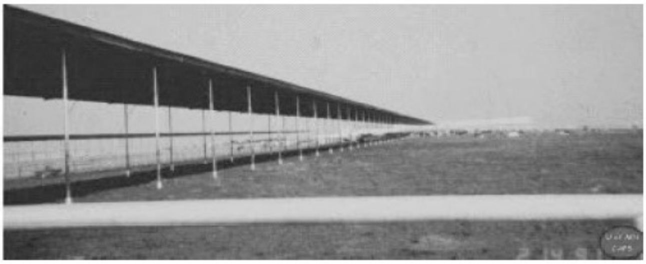
1) Shelter should be in wind direction i.e. east to west so the morning sun light gives good lighting and also being in wind direction will have good ventilation.
2) Shelter must have proper roofing covered with 3 inch dry grass to reduce the heat when sun is hot. Before putting grass paint the roof with cement and lime solution
3) Shelter must have little slope towards drain and preferably covered with wood slits.



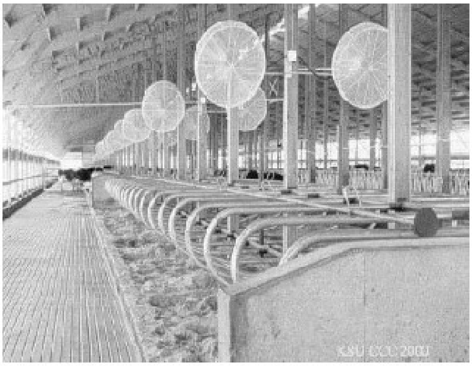
4) Shelter sides toward south north preferably closed with windows so that during afternoon and during extreme cold winter it can be closed to proved protection.
5) Shelter should have good spacing to comfortably house the milk animals. Minimum of 3 mts by 1,5mts space is required per animal. The height of the roof should not be less than 3 mts.
6) The shelter should be provided with cooling fan, water spray and large water tank with water make up provision for drinking water.
7) Shelter should be surrounded by fodder trees which not only give conducing environment but also gives fodder during drought and summer.
8) There are many animal holders who may not have their own land. Community Shelter could be constructed in village grassing land for housing their animals. This can be perhaps be undertaken under NAREGA.

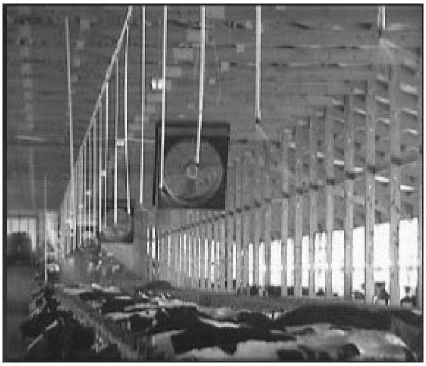
A typical sketch showing requirement of shelter is given below:

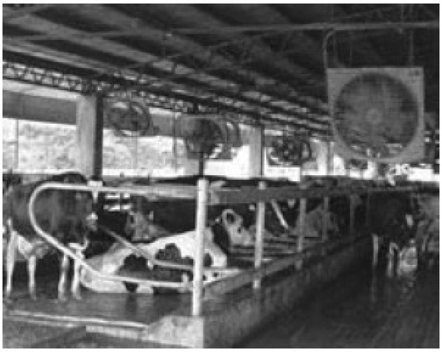
SHELTOR FOR MILK ANIMALS



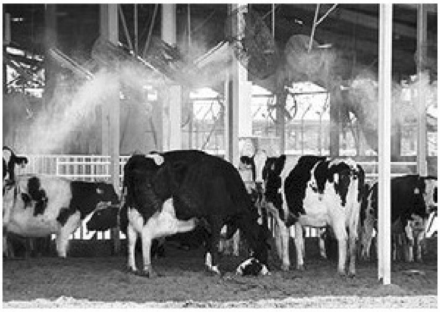
Fans Arrangement







A typical Fans and spray arrangement



A cooling pond near the shelter

3) **FEEDING PRACTISE**

The feeding practice is very important to protect the milk animals against the climate change. One has to ensure that a total feed is given to animal all through 24 hours which should be properly prepared. The feed has to be balanced with urea treated dry fodder properly cut mixed with silage green fodder, concentrated feed and mineral mixture. Fresh, palatable, high quality feed with high biological value should be provided in the feed bunk at all the time to provide maximum opportunity for feed consumption

Reduce the use of poor quality straws in the diet of livestock. Feeding frequency should be increased rather feed to be made available all 24 hours.

Mixing the ration:

It may be useful to shift feeding times to match animal behaviour. Animals tend to change meal patterns and eat more feed during the cooler times during the day hence make feed available all 24 hours of the day. Grain and fiber recommendations are as follows:

Precautions to be taken during Extreme Heat for Milk Animals:

- Dietary fat content should not exceed 5 to 6% of the total diet dry matter
- Do not exceed 55-60% concentrates in rations
- Bypass protein and bypass fats are recommended
- Water mix feed
- Provision of cold water

Precautions to be taken during Extreme Cold for Milk Animals:

- Cold weather increases feed needs of cows. Hay provides more heat during digestion than concentrate feeds.

- Cows need dry, draught-free resting area.
- Use ample amount of good, dry bedding
- Having dry teats when the cow leaves the parlour is important. One way to lessen the risk is to dip the teats, allow the dip of about 30 seconds and then blot dry using a paper towel

Precautions to be taken during Drought Period for Milk Animal:

- Preservation of fodder
- Preserve water resources
- Feeding of chaffed fodder
- Prevents feeding of poisonous plants and feed
- Prevents feeding of pre-mature sorghum (cyanide poisoning)
- Prevents feeding of moldy grains or fodder (aflxicosisato)
- Prevent over feeding due to starvation

During extreme monsoon and flood care which is to be taken for Milk Animal:

The Animals to be let free or taken to be high areas

The sufficient stock of feed to be stored at sufficient height to avoid the flood water damaging feed. The store area should be dry and water tight.

4) DRINKING WATER AVAILABILITY

Proper sized drinking water tank with availability of fresh water should be provided inside the shelter. Care should be taken that water remains fresh and cool. Milk animals should have access to water all 24 hours.

Fresh water should be available to cows after milking. Water intake may increase by 20 to 50% during heat stress conditions.

5) BREEDING PRACTISES

Care must be taken while breeding the milk animal. One must regularly record the milk per lactation of the milk animal and then decide about the semen doze. While getting artificial insemination one should know the pedigree and progeny of male whose semen is being used for AI. If the cow produced by the male must give more milk than the animal being serviced. It is advisable to carry out all in late evening or early morning. This will give better result in summer. AI must be done by knowledgeable

AI Worker to avoid repeat AI. Natural services should be avoided as far as possible.

6) REARING PRACTISES

Rearing of calf is very important. If you properly give feed and vaccination, calf will mature within 18 to 24 months and also will give good milk production. Expenses on feeding and rearing of calf to be considered as the investment and will generate good profit.

7) VACCINATION AND PREVENTIVE HEALTH CARE

The milk animals must be regularly vaccinated as advised by Veterinary Doctors from time to time and also anti worming treatment must be given at every six months. Milk animal must be washed regularly and shelter should be maintained clean. Regular treatment must be given to arrest fly and other insects.

VI. Poultry – Suggested Measures:

Rise of Temperature and moisture of the atmosphere have direct effect on poultry production and its price. The rise of temp leads to reduction of eggs production as well as it also affect the growth of birds. It reduces the mortality of birds as well. There is indirect effect that grain will become costlier due to less production during drought which will make poultry farm economically inviable. Rise in moisture will lead to disease outbreak which again will affect the farm economy. Hence both drought and heavy monsoon are bed for the poultry farming. Farmers has to safe guard the birds by taking necessary protection.

As the ambient temperature reaches ≥34°C

Mortality of birds are affected as given bellow:

- Heavy meat type chickens (8.4%)
- Light layer type (0.84%)
- Native type (0.32%) chickens.

Feed Consumption:

Decreases in feed consumption i.e.

At 31.6°C : 108.3 g/bird/day

At 37.9°C : 68.9 g/ bird/day

The egg production:

The egg production decreases as given bellow

: decreased in broiler 7.5%

: decreased in layer 6.4%

- As the shed temperature rises from 28 to 42°C, the body temperature of birds increased from 41 to 45°C during heat periods which will lead to reduction in eggs production.
- Beyond shed temp 42°C, birds would scrub led to die.
- Naked neck birds performed significantly better than the normal birds at high temperatures with respect to
- Thermo tolerance
- Growth
- Feed efficiency
- Immunity

During Extreme Heat the care which is to be taken in Poultry

- Decrease crude protein 2 % and energy 100-150 Kcal/Kg in feed composition
- Feeding early in the morning and gives water mix feed 3-4 times in day
- Poultry shed: white wash
- Plant tree which create shadow ultimately gives cooling during summer and warming during winter.
- Use of sprinkler between 11.00 to 18.00 in poultry shed and 5 mt surrounding area
- In deep litter system, thickness of litter should be reduced to 7-8 cm
- Use of ceiling fans



- Use of anti stress compound electrolyte and vitamins mix with water or feed
- Decrease 10 % birds

During Extreme Cold care which is to taken in Poultry:

- Increase crude protein and energy in feed composition
- In deep litter system, thickness of litter should be increased to 15 cm
- Use of electric heater, bookharietc for provision of heat
- Increase 10 % strength of birds
- Cover the shed and open area to prevent direct effect of chilled blow

HEAT STRESS

During Flood and heavy rain care to be taken for Poultry

Please ensure that the floor of the shed is at least 3 feet above the ground floor to avoid flooding of shed.

The sufficient stock of feed should be stored in dry and protected building. Store the feed on iron stand away from wall to avoid increase in moisture and mould.

Take the proper insurance of poultry sheds, equipment and mortality of birds due to drowning in flood water.

VII. Fisheries – Suggested Measures:

Drought:

Provide water linkage to all the ponds either by water through tankers or by pumping water from nearby reservoir. Alternatively capture the mature fishes and send to market to reduce stocking density or transfer others to alternative water ponds. In case of Capture Fisheries i.e. both marine and inland fishes either migrate or not survive.

Flood and Cyclone:

In case of Capture fisheries the flood will have positive impact but flood will affect culture ponds which are situated nearby the river. It damages the ponds and also contaminated the culture. In such case harvest the culture fish and wild fish which come with the flood water. Repair the ponds, disinfect the ponds with chemicals after the flood and recharge the fresh water.

Heat Wave and Cold Wave:

Heat and cold wave affects the fish stock, in case of capture marine and inland fishes will migrate to safer place where as culture fisheries will have large effect as fish growth will be retarded as well as breeding and rearing of fish larvae will be severely get affected. In such case one has to exchange the water from time to time during heat wave. During cold wave provide heaters with thermostat to maintain constant water temperature and aerator to maintain the oxygen level. Increase the fish density. Provide probiotics as well as fresh and live feed.

Conclusion

Compared to crops – which fail completely if rainfall fails and drought occurs. cyclone or heavy floods wash away standing crops, Livestock are more resilient with proper planning they can continue to support livelihood.

The most important supportive action is to provide drinking water and bring fodder from outside and make available through Fodder Depots. But in case this does not become possible forced migration is only solution.

Livestock do discharge high quantity of methane gas. This can be migrated by setting up of individual bio-gas plants and community bio-gas plants (i.e. case study Chhota Udaipur).

CONTINGENCY PLAN

Contingency Plan under Unforeseen Climate Change Effects

- ❖ When there may be unforeseen climate change effects observed in the atmosphere due to increasing or decreasing climate parameters following types of impacts are observed in the climates.

  The Contingency Plan is prepared by Agriculture University for each district. The general remedial measures - (as advised by Krishi Vigyan Kendra (KVK) ATMA) should be followed by farmers.

- ❖ **Flowing hot wind**
  - Irrigate the crop at shorter interval
  - Protect the crops by growing the living hedge.
  - Show the 4-5 lines of sorghum crops around the field to protect against wind effect
- ❖ **Flowing of cold wind**
  - Irrigate the crop at shorter interval
  - Burn the waste grasses of hip in the field to create the warmer effects in the field
- ❖ **Dry spell observed after the onset of monsoon**
  - 8-10 days break is not severe
  - If dry spell prolongs up to 15 day

  Irrigate the crop at critical stage of crop growth
- ❖ **Remedial measures**
  - Thinning and gap filling must be carried out in the field
  - If rainfall is not received up to 25-30 days after onset of monsoon

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by Dr. R. H. Patel, formerly Senior Research Scientist, Anand Agricultural University, Anand, Gujarat

Reduce the numbers of row in the field and inter culturing operations must be carried out in the field

- Weeding operations should be carried out in time
- Apply the supplementary irrigation in alternate furrow system in the field
- Spray the crop with 2% solutions of Urea (Hy. Castor), Cotton, Arhar)
- Delay the split application of Urea in the crops when rain is delayed

❖ **Monsoon is earlier completed than normal season**

- It gives more hazardous effect on the crop
- Apply the supplementary irrigation to the crop

❖ **Monsoon is prolonged than Normal**

- This situation is favourable to the crops
- Rabi crop like gram can be easily sown on the residual moisture under black soil condition

❖ **Water conservation operations carried out by the farmers**

1) Form the compartmental block in the field

If slope is observed less than 1% in the field build up the farm bund opposite the slop direction in the field

2) **Contour farming**

If slope is observed 1-2% in the field contour farming must be adopted

3) Strip cropping

To prevent the soil erosion in the field strip cropping cultivation adopted keeping with 6-8 raw in the field and show the spreading types crop to avoid the soil erosion in the field

4) Show the seeds on Ridge and Furrow system

Furrow should be deepened upto 15-18 cms and spaced with 30-35 cms apart. Keep 45 distance between two furrows

5) Plowing should be done in summer season

6) Form the contour/graded bunds in the fields

It is applicable where is slope is observed up to 1 to 6% in the field and total rain fall received up 800 mm

7) Alternative use of land

- Agro-forestry
- Silvi-pasture Management
- Agri-Horticulture

❖ **Work to be carried out by the Panchayat & Government:**

1. Watershed Management
2. Construction of water harvesting structures

❖ **Common packages of practices to be adopted**

1. Select the crop resistance variety which can withstand under aberrant weather conditions
2. Select the proper method of planning
3. Use sufficient quantities of organic manures in the field
4. Use various methods of water conservation in the field
5. Use advance method of micro-irrigation system

STRATEGY FOR RESTORATION

- Climate Change has brought in recent years. Some major calamities which have affected entire agriculture and livelihood in affected areas.
- To illustrate in the current year
  - ❑ Uttarakhand cloud bursting
  - ❑ Odessa cyclone
  - ❑ International level – Phillipines cyclone
  - ❑ At local flooding in Navsari district and part of Anand District
- Such devastation cannot be remedied by existing mitigation or adaptation strategies.
- It needs total rehabilitation of agriculture activity which is not forming part of current disaster Management strategies which cater to cease emergency situation and provide relief measure.
- What is needed is total restoration

Impact of disasters and action needed		
Over –topping of fields /damage to check dams due to floods	• Repair check dams. • Restore washed away soil.	Cropping pattern based on fresh Soil Health & Moisture Analysis along with making available of seeds and other inputs.

Impact of Disaster and Action Needed	
Permanent increase in sea level and submergence of agriculture land.	• Farmers have to be given alternative land • If feasible protection wall has to be constructed along with plantation of mangroves outside of the wall
Washing out of soil strata and spread of salinity due to cyclone both underground and over-ground.	• Soil replacement • New cropping pattern based on fresh Soil Health & Moisture analysis along with analysis of a. sub soil water strata b. water availability for irrigation from wells/tube wells • Making available certified seeds and other inputs for cropping pattern suggested and agro advisory on new crop management – Kutch case studies

Impact of Disaster and Action Needed	
Loss of tractors/storage bins/ agriculture implements. Mortality of livestock and poultry	• Replacement of all these under government support and insurance

MULTIPLE SOURCE OF INCOME

Objective of climate smart agriculture is to make farmers and their income resilient to climate change. This can be made by providing multiple source of income such that If one fails, the other sustains. This initiative needs to be guided by local public governance system and civil society.

- **Poultry / Cattle with Crop**

  Crop system and livestock when they are together, waste of one is resource for other. Milch cattle cows – weekly cash flow to family when incomes from crops are at the end of season. Animal like cow provide gobar and urine which is manure to crops. While most crops residue is feed to animals. Both reduces cost and enhance efficiency. Further, livestock constitute a capital which can be converted into cash and in-case even if one fails, other supports and thus. Offer a way to escape poverty and provide coping mechanism in vulnerable and variable related environment.

- **Rice – Fish:** This can be concurrent production system and is prevalent in some parts of our country. Can be useful to propagate rice growing areas of Navsari and Anand. It can add to income and also provide balanced diet.
- **Agro Forestry:** Use of trees and shrubs as a part of agriculture system.
  - It prevents soil erosion
  - Facilitates water infiltration
  - Diminishes impact if extreme weather
  - Trees also provide fodder to livestock – improves soil fertility due to enhanced nitrogen and carbon sinks
  - More of all, its sale provides alternative income.
  - This already exists in the districts at some plans but needs to be expanded.

❖ **Alternate Land Use Systems……. Agroforestry…!**

- Approximately 1.2 billion people (20% of world population) depend to a large extent on AF products and services for their survival (ICRAF 2000)
- About 400 m ha area is under AF
- Approx 38 Gt (billion tons) of carbon could be sequestered (30.6 GT by afforestation & 7.4 Gt through increased AF practices) during next 50 years (IPCC 2000)
- Productivity of some clonal plantation is of the order of 20-50 m3 per ha per annum
- In one survey 56 AF practices have been found more profitable than sole cropping and in 40% of cases financial returns were at least 25% more than sole crop (Current et al.)

❖ **Afforestation on Highly Alkali Soils**

Source : Dr. J.C. Dagar, Formerly ADG (ICAR)

❖ Cultivation of Fruit Trees on Sodic Soil

Psidium guajava

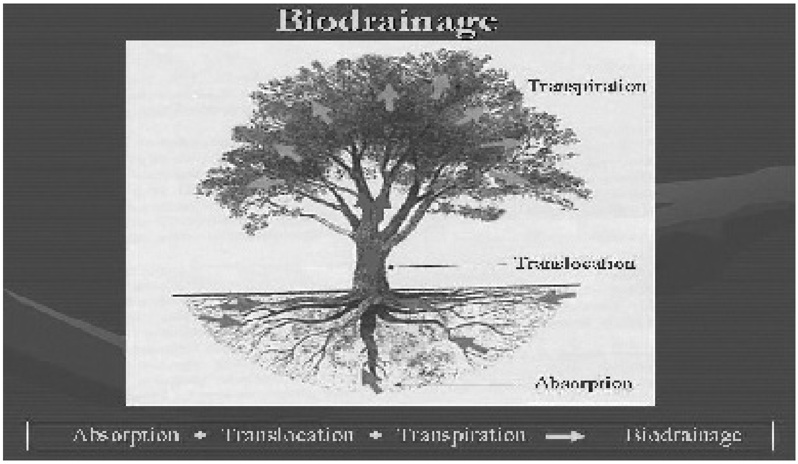
Source : Dr. J.C. Dagar, Formerly ADG (ICAR)

❖ Agroforestry with Saline Water

Barley with karonda (*Carissa carandas*)

Source : Dr. J.C. Dagar, Formerly ADG (ICAR)

❖ **Control of Water Logging**



Source : Dr. J.C. Dagar, Formerly ADG (ICAR)

❖ **Mangroves: Challenge for Rehabilitation???**

Source : Dr. J.C. Dagar, Formerly ADG (ICAR)

- **Agriculture and Handicraft:** Handicraft including tailoring provides alternate source of income and sustains farmers in time of drought when both livestock and crops provide low or no income in rainfed areas during summer.

Some examples of farmers of Abdasa Block which an arid area of Kutch District are in following table.

Multiple Source of Income
Abdasa Arid Block – Kutch – Gujarat

Sr. No	Name Of Village	Name Of Block	Name of Member	Occupation	Best Year Income	Week Year Income	Livelihood Project Joined After				Income from alternate source
1	Charopadi Nani	Abdasa	Sodha Ladhubha Aamrji	Farming	30,000	8,000	Animal RLF	Farming Inputs	Sewing machine		40,000
2	Charopadi Moti	Abdasa	Mandhara Mariyambai Sidhik	Farming	50,000	12,000	Farmer loan	Sewing machine	Ration shop		30,000
3	Charoapdi Moti	Abdasa	Maheswari Tejbai Vachiya	Farming	45,000	15,000	Floor mill	Asset(Tractor)			54,000
4	Jethamalpar	Abdasa	Bhatt Bhupatram Mohbatram	Farming	55,000	30,000	Animal RLF	Land levelling			40,000
5	Bhoa	Abdasa	Chuahan Khetubha Bhojubha	Farming	30,000	12,000	Animal RLF	Land levelling	Sewing machine	Kitchen Garden	55,000
6	Rodasar	Lakhapat	Maheswari Kanbai Gopal	Farming	50,000	20,000	Animal RLF	Ration Shop	Kitchen Garden		72,000
7	Ukir	Abdasa	Luhar Hanifabai Alimamad	Farming	30,000	10,000	Ration Shop	Home Floor Mill	Kitchen Garden	Animal RLF	48,000
8	Ukir	Abdasa	Luhar Kulsumbai Haji	Farming	35,000	12,000	Sewing machine	Animal RLF			40,000
9	Bara	Abdasa	Maheswari Lakha Karu	Farming	50,000	25,000	Seed Support	Crop Loan	Kishan Credit Card	Irrigated Farming	1,00,000
10	Bara	Abdasa	Jadeja Takhatsinh	Farming	60,000	20,000	Animal RLF	Irrigated Farming	Diesel Engine	Crop Loan	90,000

Source: Shree Vivekanand Research & Training Institute, Mandavi, Kutch, Gujarat, India

Multiple Source of Income
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2	Charopadi Moti	Abdasa	Mandhara Mariyambai Sidhik	Farming	50,000	12,000	Farmer loan	Sewing machine – Rs. 15,000	Ration shop – Rs. 24,000		39,000
3	Charoapdi Moti	Abdasa	Maheswari Tejbai Vachiya	Farming	45,000	15,000	Floor mill – Rs. 42,000	Asset(Tractor) - Rs. 48,000			90,000
4	Jethamalpar	Abdasa	Bhatt Bhupatram Mohbatram	Farming	55,000	30,000	Animal RLF	Land levelling			40,000
5	Bhoa	Abdasa	Chuahan Khetubha Bhojubha	Farming	30,000	12,000	Animal RLF – Rs. 25,000	Land levelling	Sewing machine -Rs. 2000	Kitchen Garden – Rs. 5000	55,000
6	Rodasar	Lakhapat	Maheswari Kanbai Gopal	Farming	50,000	20,000	Animal RLF	Ration Shop	Kitchen Garden		72,000
7	Ukir	Abdasa	Luhar Hanifabai Alimamad	Farming	30,000	10,000	Ration Shop – Rs. 12,000	Home Floor Mill – Rs. 18,000	Kitchen Garden	Animal RLF	48,000
8	Ukir	Abdasa	Luhar Kulsumbai Haji	Farming	35,000	12,000	Sewing machine	Animal RLF – Rs. 60,000			60,000
9	Bara	Abdasa	Maheswari Lakha Karu	Farming	50,000	25,000	Seed Support	Crop Loan	Kishan Credit Card	Irrigated Farming – Rs. 100000	1,000,00
10	Bara	Abdasa	Jadeja Takhatsinh	Farming	60,000	20,000	Animal RLF	Irrigated Farming – Rs. 1,00,000	Diesel Engine	Crop Loan	10,0000

Source: Shree Vivekanand Research & Training Institute, Mandavi, Kutch, Gujarat, India

WOMEN FARMERS

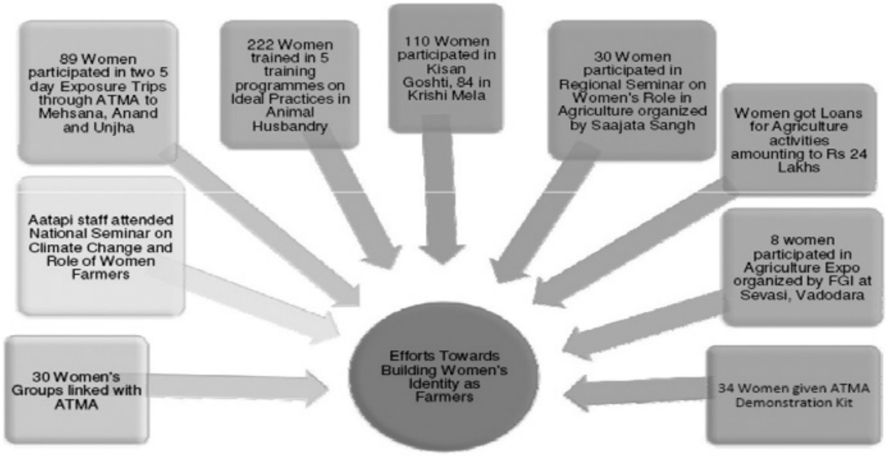
Women play important roles in agriculture production. These roles pertain to all aspects of crop production / protection, management of livestock, farm animals / husbandry and fisheries but are treated as "workers" and not farmers.

In recent times, women are increasingly replacing men in all farm activities – they are now new farmers – no longer with partial responsibility but with full control on farm decisions as venture to   in search of employment. This is in addition to routine domestic and family functions (house-keeping, cooking, children upbringing etc.). This signifies a major shift in the roles and responsibilities in a men-centric extension system need special capacity building for CSA.

Efforts to build capacities of women in agriculture are, however, constrained by the fact that agriculture tools, equipment and extension communication strategies are predominantly men - centered. The need is to ensure that women are adequately informed to take on farm decision in abnormal weather changes, made available appropriate tools and techniques that optimize on time and reduce stress while handling them.

Meeting of Women Farmers at MGLI, Ahmedabad

SGSY Training Programme for Self Help Groups



AATAPI is an NGO working in Bharuch district. It has integrated development programmes. This involves focus on women farmers and creating local leadership

SOME STORIES OF SUCCESSFUL WOMEN FARMER

Village woman of Kutch district generating bumper production and windfall profits from farming of dry mate (Kharek)

Women can play a miraculous role in farming parallel to male farmers if they are empowered to decide on agriculture related issues like land preparation, selection of crops, procurement of seeds and other inputs, mix and intercropping patterns, periodic growth of plants, input supply timing and up-keeping till the harvesting stage.

Here is a story of a woman who greatly succeeded in non-conventional farming. Mrs. Bhavnaben Bharatbhai Patel of Ratnaper Village, Ta- Mandvi, Dist- Kutch selecetd cropping of dates in her 150 acres land.

In 2009 her total production was 75 tons, with a sales value of Rs. 55.00 lacs and the profit of Rs. 30.00 lacs, which rose to 185 tons with sales of Rs. 80.00 lacs and profit of Rs. 45.00 lacs. The average returns on sales are above 50%. Such a large volume of production is intelligently marketed through the Gujarat Agro Marketing which helped a lot in fetching better price for the produce.

Moreover, she also followed the intercropping pattern of farming with the cropping of watermelon, muskmelon, mango etc. Besides maintaining and enhancing the soil production, she uses organic liquid which is manufactured in her own plant. For her such amazing success, she was awarded "ATMA Award" and "Sardar Patel Award".

Literate Women Farming Managing Cattle Farm on a Professional Activity

Generally cattle farming is not an attractive profession for literate people. But Mrs. Jayaben Mansinhbhai Dahima of Devdi Village of Kodinar Taluka, Dist- Junagadh has studied upto M. A. Instead of going for a white collar job in the urban area, she chose to live in her own village only and to develop the traditional cattle farming family business. Her financial condition was moderate and the herd stock was only 3 (2 buffaloes and 1 cow), in 2010. She put moderate money on scientific shed and use of chaff-cutter for dry and green fodder. She decides the appropriate mix of fodder and concentrated dan for the dry and milky cattle. She did not put more money on new cattle, but she followed rearing up of her own cattle breed following scientific pattern. The herd stocks increased from 3 in 2010 to 9 in 2013 (6 buffaloes and 3 cows). The milk production per cattle increased considerably due to the scientific approach in cattle farming. Her sale of milk increased from Rs. 0.6 lacs in 2009 to Rs. 4.10 lacs giving a return on investing between 40% to 50%.

Moreover, she uses the dung for vermi compost and urine as organic liquid in her own 4 acres field. Such use of dung and urine increased the production of green fodder for her own requirements and also gets remarkable farm produce giving handsome returns.

Moderately literate village woman manages a scientific cattle farm of 225 HF cows

Among all the agricultural activities, cattle farming provides handsome returns on investment of about 35% with a payback period of only 3 years i.e. one can recover the investments in assets from the earnings of the asset, keeping the asset intact.

A moderately educated women Mrs. Kantaben Ramjibhai Chaudhari of Bapupura, Ta-Mansa, Dist- Gandhinagar digested this business principle through her smart self understanding. She learnt some tricky lessons of cattle farming, which is a community based profession of Chaudhari community in Gandhinagar, Mehsana, Sabarkantha and Banaskantha in Gujarat. They are the centres of white revolution parallel to Anand and Kheda districts.

She has constructed a low-cost cattle shed on scientific basis for 225 HF cows. The roof tops, roof-heights, open walls with free flow of air, slope of RCC flour towards drain and sufficient clean water supply are provided on scientific standards.

She procures about 25 liters of milk per day per cow during the lactation period which is nearing to the highest standard of milk production. Total milk production increased from Rs. 2.45 lacs liters in 2011-12 to Rs. 2.92 lacs in 2012-13. She earns the returns of about 25% to 30% on the investments.

She encourages other men and women to go for such cattle farming business the way she has followed.

She earned the Award of 'Sagar Samrat' awarded by Mehsana District Co-operative Milk Union Federation for her remarkable success.

A Tribal woman entrepreneur combats against the pitiable situation of malnutrition through value addition of agro product NAGALI

The problem of malnutrition in general and that of rural poor children in particular has become an eye-opener for the politicians and local leaders. One tribal woman of Vaghai, Ta- Ahva, Dist- Dang, Mrs. Bhartiben Chhitubhai Patel brought a remarkable solution to this problem through the development of value – adding agro product – Nagali. She is only 12^{th} standard pass, but she possesses creative ideas and their practical applications required for an entrepreneurial skill development.

She identified an agro product "Nagali" and found that this product possesses rich nutritive contents. Through its processing, she added value and made it available to rural population at an affordable price.

The nutritive contents of Nagli and its uses:

- High carbohydrates and low fat : This is most suitable for people who intend weight losing and fattiness.
- It is rich in calcium : It strengthens the bones. Thus, it is useful to children and aged people.
- It has little cholesterol contents: It provides nutrition and prevents the blood pressure and heart attacks.
- It contains less sugar contents: It is useful to the diabetic patients
- It has rich iron contents: It is very useful to patients with leukaemia and poor properties if red cells in blood.
- It improves quality and quantity of milk of breast – feeding mothers. Thus, it prevents the malnutrition of poor children of rural population.
- The green –grass possesses high nutritive contents. It can be used as a cheap and valuable cattle feed.

Nagali Value Addition:

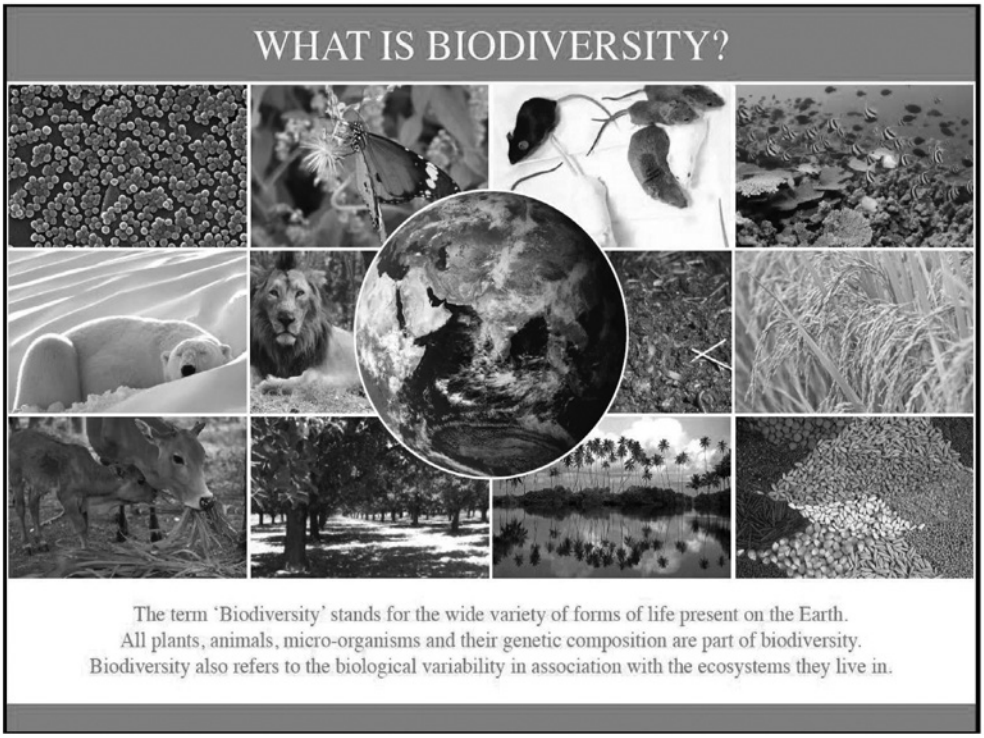
Instead of a raw-use of Nangali, it can be used as a value adding inputs in the agro based food processing industries as under:

- It adds into the existing food stock with a diversity
- It can be used in the making of the following food – items
    - Biscuit
    - Nan-khatai
    - Sukhadi
    - Ladu
    - Chakari
    - Papad
    - Dhosa

Thus, a moderately educated tribal rural woman provides an encouragement for the woman entrepreneurship in general and for the women of rural areas in particulars. She opines that the creative thinking on the available opportunities can create miracles for smoothening the agonies of the human sufferings.

Source: Dr. R A Sherasiya, Director, Agricultural Technology Management Agency, Gujarat

APPLIED BIODIVERSITY



Biodiversity is also helps to survive plants/crops. Some of species have high value as medicinal/health products. For example :

Some well-known income yielding species (Herbal Plants)

Brahmi

(Botanical Name: Bacopa Monnieri)

Promotes clarity in thought. Increases

calmness, memory, concentration and learning

Ashvagandha

(Botanical Name: Withania Somnifera)

Helps in increasing stamina and energy.

Decreases anxiety

Aamla

(Botanical Name: Phyllanthus Emblica)

Is a rich source of Vitamin C. Helps in improving body's immune system.

Neem

(Botanical Name: Azadirachta Indica)

Keeps the skin healthy. Helps in decreasing skin disease and used in bio-pesticides.

Khatti Bhindi

Helps in digestion, decreasing diabetes & blood pressure

Case Study

Moringa Farming – Drumstick Tree

Moringa farming	- Commonly known as Drumstick tree
Place – Kunjrao	- Anand
Name of Farmer	- Shri Dipen Shah (Mo. – 972772977)

Value of drumstick as a health food contains nutrients, antioxidants, anti-inflammatory, amine acid etc.

Needs little water, marginal fertilizer, high yield of pods

Soil can be grown rainfed, semi-arid, arid areas – a drought resistant tree

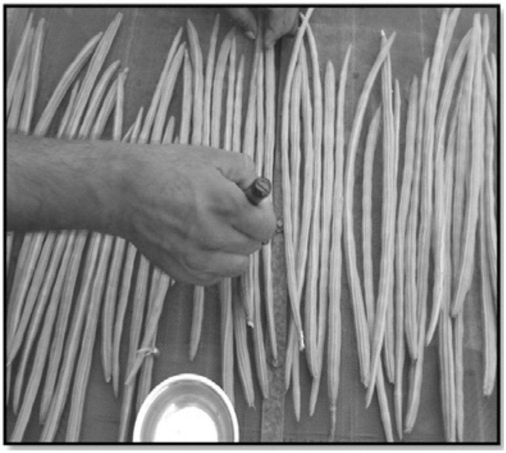
Photo two photos from presentation

A part from Drumstick, leaves used as salad. Drumstick can be converted into powder. There is Gum secretion on the tree which is used as a Ayurvedic medicine.

Moringa can be planted by seed or by stick

Seed planted moringa's fruit are plucked easily

Cleaning and wax coating of moringa pods



Packing of moringa pods for market

Drying of moringa leaves

Grinding and packing of moringa dry leaves

Source:Moringa Farming and its Value Addition – Shri Dipen M Shah

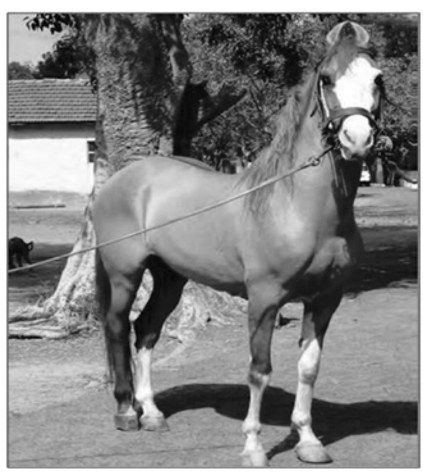
Biochar

Biochar is a stable, carbon-rich form of charcoal that can be applied to agricultural land as an element of agronomic or environmental management. It can be produced by pyrolysis, where biomass is heated with little or no oxygen (Sparkes and Stoutjesdijk, 2011). Possible biomass sources for biochar include: milling residues (e.g. rice husks, sugar cane bagasse); crop and logging residues; biofuel crops; municipal wastes; and animal manure. The suitability of the biomass for biochar production depends on its lignin content (Eagle *et al.,* 2012).

Biochar, because of its porous nature, high surface area and its ability to absorb soluble organic matter and inorganic nutrients is thought to have benefits for sustainable agricultural productivity. It increases biological activity and improves nutrient use efficiency, hence reducing NO2 emissions and carbon sequestration. The use of biochar is new and more research is needed on the potential benefits and risks of its use in agricultural soils. There is a high variability in properties and its cost effectiveness depends on the biomass source and distance to the pyrolysis plant. Also, not all soils or crops show the same improvements when biochar is applied, and there may be risks associated with increased alkalinity.

Source : Climate Smart Agri. Source Book , Soils and their Management for CSA, World Bank 2013

The Original Breeds

Kathiyawadi Horse Kathiawadi Horses are a breed originating in Gujarat, India, which resemble Marwar and the Arabian breed from which they descended. Kathiawadi was originally bred as a desert war horse to tread over long distances, in rough terrain, on minimal rations. They are currently used as mounted police horses and also for military purposes and in sports. They sustain heat stores.	

Gir Cow Gir breed Cows date back at least 5,000 years as one of the few original Zebu or Indus breeds. They are hardy and can withstand weather extremes and heat stores. On the other hand hybrid cows cannot adapt to extreme changes in local conditions. This lesser adaptability leads to less productivity of milk. Gir cows have long intestines. This aspect is believed to help yield better quality milk with high mineral content compared to hybrid and other cows. The dung and urine of local breed cow is useful to maintain fertility of soils. They are capable of travelling long distances and can migrate if contingency requires.	

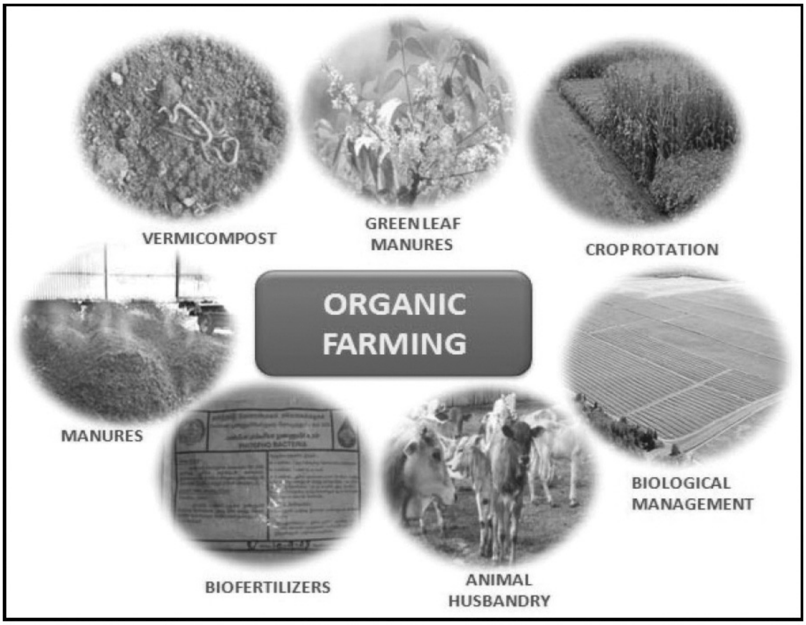
ORGANIC FARMING

A study by Rodale Institute - United State of America has established that organic farming can play a very important role. In one example of organic farming, a 23-year experiment by the Rodale Institute compared organic and conventional cropping systems in the United States found that organic farming increased soil carbon by 15-28 percent and nitrogen content by 8-15 percent.

The researchers concluded that if the 65 million hectares of corn and soyabean grown in the United States, were switched to organic farming, a quarter billion tons of carbon dioxide (or about 4 percent of annual U.S. emissions) could be sequestered.

Organic farming as understood in India is "Sajeev Kheti". It does not envisage use any form of chemicals in agriculture. This was ancient practice of agriculture. But due to regular use of land and soil degradation the Current Agro Advisory on Organic farming is to use balanced mix of chemicals and organic inputs. This reduces cost of farming by 20% to 25% by use of crop residual urine of cows etc.

Complete organic farming has many handicaps. First it requires International certification. Secondly no other crop which is not an organic can be taken



Source: Cittion: Lotter D.W. 2003, organic agriculture J Sustain Agric 21

even as a second crop. Thirdly market for such products is very limited, but can be sold as a value added health products. For small farmer, its viability is very low hence small farmers need to be cautious about embarking on it. Further in out country, not all farm lands are suitable for complete organic farming. Majority suffer from lack of certain nutritional content which can not only be met by organic input.

Hence farmers are advised to select it based on Soil Health Analysis and adopt mixed input. Farmer can also identify contain trees which are organics in nature like Neem Trees, Turmeric, Drumsticks, Indian Gooseberry, Jambolan Plum etc. Their fruits are sold generally but can be sold as organic and fetch higher price.

BIO-TECHNOLOGY

Biotechnology plays a vital role in developing crops which are climate resilient

Genetically Modified (GM) seeds are under cloud but crops like BT cotton gave excellent results to give higher income due to reduce cost because of non-use of pesticides.

Biotechnology needs to be used in overall agriculture by promoting tissue culture, bio- fertilizer and pesticides.

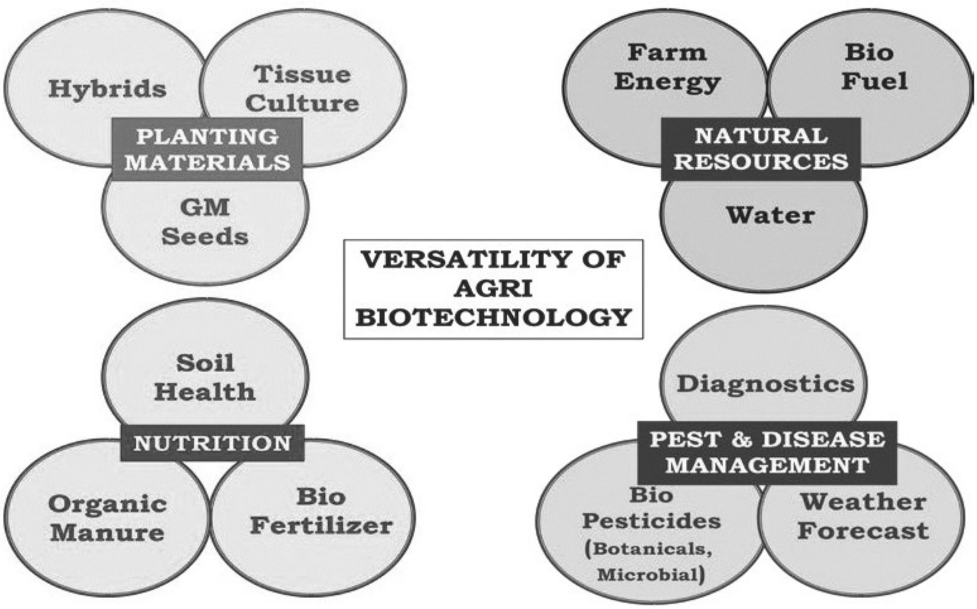
It has a key role to solve development issue and to provide (a) rapid development (b) provide sustainable livelihood to small farmers (c) meet challenge of food security (d) provide food at reasonable price to hungry millions.

Biotechnology in agriculture is most often mis-understood with G.M. crops. In fact Biotechnology can play very important role in following areas.

1. Tissue culture for plants including crops
2. Cloning-including scientific advancement of grafting
3. Bio-pesticides
4. Bio-fertilizers
5. Livestock – Vaccines
   – Cross breeding
   – Embryo transfer
6. Agro Processing

B T cotton of India is a well-known case of biotechnological intervention which has increased yield, reduced cost and thereby increasing the overall cotton production in the country phenomenally. In Gujarat cotton production has increased from 20 lacks bales to 80 lacks bales and productivity equals world's highest yield and majority of farmers have benefited.

It is recommended that any such intervention should be applied after field trial to ensure introduction of varieties which do not have adverse impact on human being or soil. And, of course, seeds need to be available to framers easily, at a reasonable price. Further impact of increase on temperature on resistance to insects/worms need to be continuously monitored.



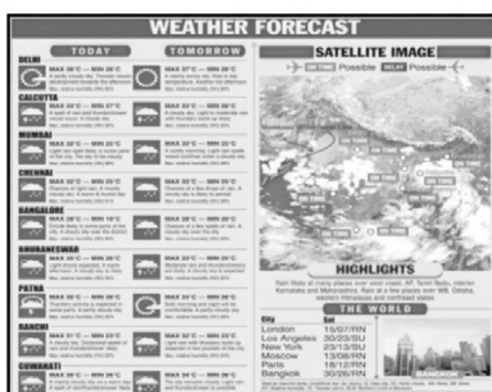
WEATHER FORECASTING

Early Warning System

It is important to realize that erratic weather changes have already brought huge adverse impacts on the entire Agriculture Sector, Crops – Horticulture, Livestock and Poultry – Birds and Fisheries. But this can be mitigated by (a) advance information and warns by meteorological department though FM Radio & TV (b) Agro-Advisory – on information of impending weather forecast and un-usual pattern provided by Krishi Vigyan Kendras (KVKs) which interlinked with India Meteorological Department (IMD) on internet. In the Farmers Interaction Meet with Experts during National Conference organized by NCCSD at Anand Agricultural University (AAU) – March, 2013, it was revealed that only 10% of farmers have access to weather forecasting.

It is need of the hour / pertinent to communicate to farmers about:

- Possible rainfall pattern-long term
- Mid-season correction, if any in same
- Weekly forecast
- More specific forecast on day to day basis for unseasonal or heavy rain, high wind velocity, frost and spell of heat and cold.



- Agro-Advisory can be developed by simulation model and communicate to farmers in time to time. Only this can prevent the crop failure.
- Local weather station that have set up by IMD need to be multiplied and need to be two way communication centre –
    - I. Provide information at local level about impeding changes – weather forecast
    - II. Receive data of actual changes in temperature, wind velocity and actual rainfall pattern and analysis done to provide further feedback on Agro Advisory.

This clubbed with soil health analysis is the most crucial information to farmers for saving their crops due to unforeseen weather changes for example like:

Increase in heat – temperature	Provide irrigation
High wind velocity	No spraying of pesticides
Unseasonal rains	Delay harvesting on that day – cover harvested crops
Long interval in rains after sowing and first shower	Ready for alternate sowing and procurement seeds

- While many of advance countries do have technology and communication system, most of developing countries do not have this. There is, therefore, need for knowledge transfer with international cooperation in this regard.

RURAL YOUTH

Rural youth across the world are becoming increasingly enterprising . They look forward to higher income at a rapid pace and like to be equal with their urban counter parts – but agriculture, most often, does not yield quick income and in the context of climate change youth prefer to abandon farming and migrate to urban centres.

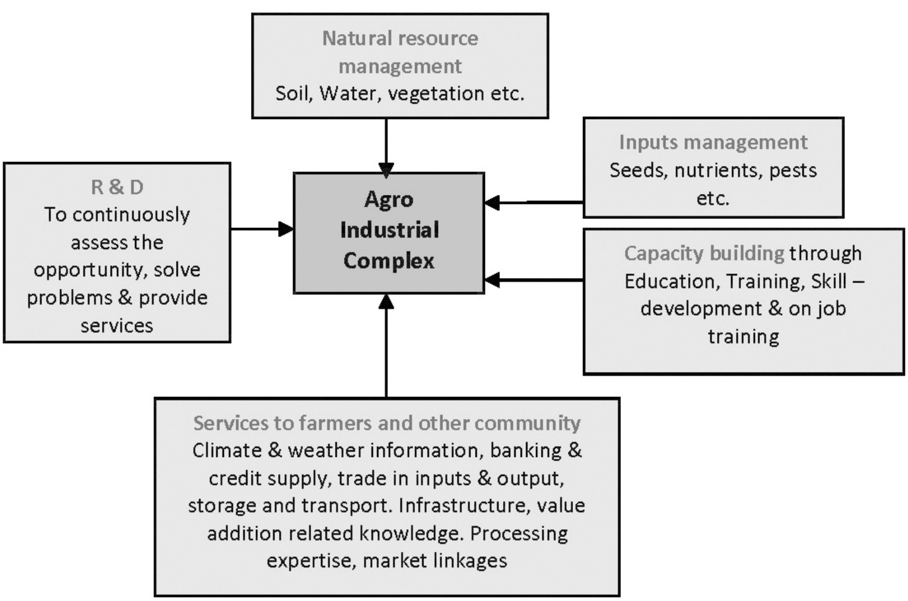
Another major adverse impact on rural youth is easy influence by groups which encourage internal violence, spread of terrorism and missappropriate others income through extortion . In India, this is prevalent in some districts and is known as “Naxalism”. Since the rural youth are susceptible to these easy income activities they have to be made cognizant and capable to gain better income through modern methods of farming like :

- Oriented to scientific agriculture
- Educated in multi-skills
- Moved to set up micro enterprise or agro service centre
- Adopt modern agriculture, protected agriculture through green house
- This has to be with addition of modern infrastructure in village

RURAL INDUSTRIES

We have rapid industrialization - in fact, very good growth in agro industries, but it is only in urban centers. But if agro industries can be based in villages, that can play a major strategic role by providing local employment, better price to agri produce & support wealth creation and economic growth in areas that have been affected by internal conflicts, natural catastrophes or out-migration resulting from uneven development. It reduces migration, especially of young unskilled labour. It can also reverse migration trends by offering new employment opportunities. It can alleviate social pressures and demands on public services within the city.

Further, local processing reduces transport cost, wastage due to moving products and high storage cost – while it provides quick income realization.



The opportunities lie:

- Agro service centre – tool bank
- Agro service centre – inputs supply
- Agro service centre – procurement for retail outlet
- Livestock farm
- Local grading – packaging & transport
- Local primary processing with cleaning, grading and packaging
- Workshop for repairs – tools and equipments
- Producing ready – to – eat food like papad, pickles etc.
- Computer service centre

Some Successful Experiences are described in following Success Stories of Agro – enterprises by young persons

Name **: Ambaliya Amitkumar K.**

Taluko **: Junagadh**

District **: Junagadh**

After B.Tech (Agri. Engineering), he started his Agri Business Centre under the banner of “Sorath Agri Tech” located in Junagadh. His major focus of business is supply of Micro Irrigation Equipments. He also provides agricultural extension by direct contact. Presently he is serving farmers of 6 villages of Junagadh taluka.

Name : **Chauhan Agarsinh A**
Taluka : **Anand**
District : **Anand**

He has B R S (Bachelor of Rural Studies) degree and Master's Degree in Social welfare. He realized the significance of high-tech agriculture in Nursery Business and he started his own Nursery in Prantij (Dist- Sabarkantha) on a 2 acres highway sight land. It proved to be a great success.

He operates under the banner of "Devku Nursery". His seedling and hardening activity helped numbers of farmers to increase their yields on flowers, fruits and vegetables cultivation. His major thrust is on tissue culture technique applied to Taiwan Papaiya and Bananas.

Name : **Ukani Jenish R**
Village : **Chikhalia**
Taluko : **Upleta**
District : **Rajkot**

Dr. R. Ukani Jenish is from a farming family and did his B.V.Sc. from Anand Agricultural University in 2008 with an objective to make a career as a veterinary doctor. He served in veterinary clinics for about two years and gained valuable first hand experience and later obtained M.V.Sc. from Navsari Agricultural University in the year 2011.

He was trained under AC- ABC Scheme conducted at Navsari Agricultural University by the International School for Public Leadership (ISPL), Ahmedabad. During the training, he analysed the market opportunities and found that there were only three pet clinics and one animal beauty parlour in Rajkot. However, these were operating on a small scale and were treating dogs only. He discovered that there was no clinical facility for nearly 400 horses in and around Rajkot district. Moreover, there were no ambulance facilities with veterinary doctors at Rajkot.

He started a Pet Clinic "Krishna Veterinary Hospital" at Rajkot in the year 2011 to fill the extension gap. The clinic has all sophisticated equipments such as Ultra Sonography and Radiography for diagnosis. Treatment is given to small animals and dogs in the clinic. He performs major surgeries on Cattle and Buffaloes. Besides, he started a mobile clinic, which consists of a vehicle with a doctor, medicines and diagnosis kit, and moves to the farmer's site for treatment. He is offering quality extension services through the mobile clinic, in areas where Government doctors cannot approach. He is covering around 500 farmers in and around Rajkot district.

Name : Zinzala Ramesh D.
Taluko : Kamrej
District : Surat

Mr. Zinzala Ramesh D. earned the B. Sc (Agri) degree from Gujarat Agriculture University, Navsari in 2000 with first class. He initially started his carrier in a private company as field officer supplying agro inputs. After 8 years of job he then decided to start his own business unit. He started his business unit as a partnership firm in March, 2010.

Considering the importance and growing use of organic manure, his company decided to manufacture and supply the organic manure. They have developed a standard quality of organic manure packed in standardized bags with a brand name of "Vardan". They are not only involved in marketing the organic manure as a substitute to chemical fertilizers but also arrange demonstration of it's use and benefits before the farmers groups and the farmers club. Largely farmers have rated their products well and given positive feedbacks. Vardan brand today is well appreciated in 7 districts of South Gujarat covering more than 5,000 farmers.

Source: AC-ABC Trained Successful Entrepreneurs - Dr. D. R. Patel, Nodal Officer, ISPL, Ahmedabad

These are also examples of young enterprising individuals who have started their own business and made profitable income through Agri Clinics and Agri Business Centre (AC-ABC) scheme. Government provides free training and assistance to obtain bank loan and also provides subsidy for seed capital. All above entrepreneurs are trained under AC-ABC by International School for Public Leadership (ISPL) which is an associate organization of NCCSD.

GRASSLAND DEVELOPMENT

The grasslands are the ‘common’ lands of the community and are generally presumed to be the responsibility of none. They are the most productive ecosystems in the sub-continent, and in spite of being beneficial all, are controlled by none .

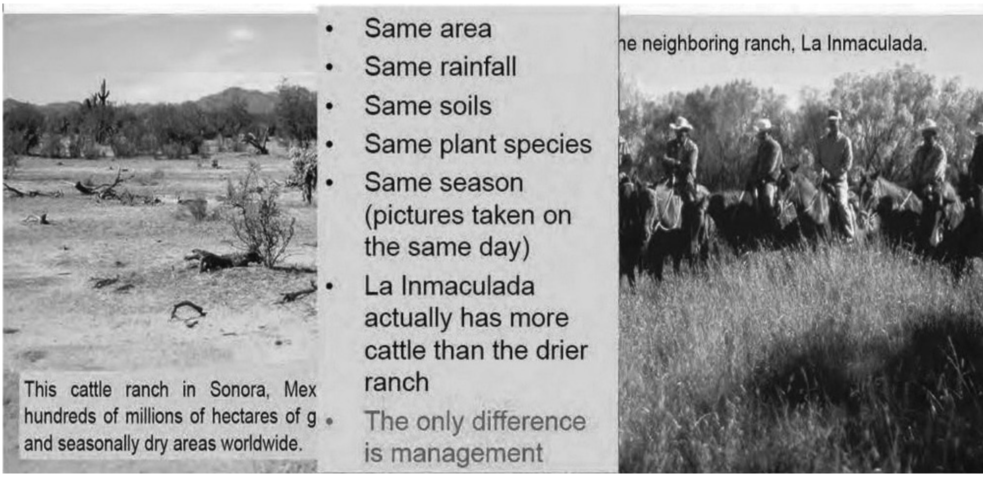
Pasture lands, which are already highly degraded in many semi-arid parts of India due to the absence of appropriate management practices, particularly in arid and semi arid regions, are situated in highly ecologically sensitive contexts. There is high risk of degradation of vegetation cover and soil erosion. Recurrent droughts lead to loss of vegetative covers. During monsoon when heavy rainfall hits the undulating terrain after long dry periods, large amount of silt and sand are washed away by runoff. As the soil cover is very thin in these regions, few cycles of erosion convert the land unproductive.

Due to lack of proper management and improvement, productivity of grasslands is very low. For their proper management and improvement focus should be on following points:

- Improved cutting and grazing management
- Removal of bushes and other species
- Use of fertilizers and manures
- Introduction of suitable legumes

Appropriate grassland management practices contribute to adaptation and mitigation, as well as increasing productivity and food security and reducing risk of drought and flooding. Well-managed grasslands provide many co-benefits that are critical to adaptation. Risks associated with prolonged drought periods and unreliable rains can be offset by the increased water infiltration and retention associated with organic matter accumulation in the soil. Moreover, this will improve nutrient cycling and plant productivity and, at the same time, enhance the conservation and sustainable use of habitat and species diversity. Grassland management is thereby a key adaptation and mitigation strategy for addressing Climate Change and variability.

INTERNATIONAL EXPERIENCE - CONSUMPTION OF CO_2 PER HECTARE



Source : Tony Lovell – Soil Carbon P/L Australia

CONSUMPTION OF CO_2 PER HECTARE

If a hectare of soil 33.5 cm deep, with a bulk density of 1.4 tonnes per cubic metre is considered, there is a soil mass per hectare of about 4,700 tonnes (Tony Lovell)

If appropriate management practices were adopted and these practices achieved and sustained a 1% increase in soil organic matter (SOM), then 47 tonnes of SOM per hectare will be added to organic matter stocks below the soil surface.

This 47 tonnes of SOM will contain approximately 27 tonnes of Soil Carbon (I.e. 47 tonnes at 58% Carbone) per hectare.

In the absence of other inputs this Carbon may only be derived from the atmosphere photo-synthetic process. To place approximately 27 tonnes of Soil Carbon per hectare into the soil, approximately 100 tonnes of carbon dioxide must be consumed out of the atmosphere by photosynthesis.

A 1% change in soil organic matter across 5 billion hectares (estimated waste land in the world) will sequester 500 billion tonnes of Physical CO_2.

SAFETY NET TO FARMERS

The insurance cover already exists for both crops, Horticulture and Animal Husbandry. It is in implementation since last many years. Key is to aid farmers take benefits of it. Such insurance covers have a very low premium and are directly operated through bank. Both Government of India and State Government contribute towards the premium / insurance money by way of subsidy.

Safety nets are a form of social protection. They comprise of programmes - generally promoted by Government. This is –

a) Time unforeseen changes in climate leading crop failures and cattle / poultry death	Crop Insurance – Cattle Insurance Schemes already exist. Farmers need to be informed and moved to insure their assets.
b) Employment in community programme under NAREGA	Now available round the year
c) Total devastation due drought or flood	• Food voucher • Subsidies for seed- tools – inputs • Alternate employment in community work • Re-build of housing and support for household items • Replacement of livestock

PROTECTED AGRICULTURE

This controls weather parameters- can be round the year and provides sustained income. This is basical approach adapted by Israeli Farmers and now increasingly popular. It is known as Green House Approach. Wherein water moisture and nutrient supply is regulated through computer system. The Government provides subsidy. This needs to be propagated in big way as it provides assured agriculture. Marketing links are important. It is capital intensive.

Some Case Studies

Successful farmer of cluster bean (Guar Gum) cultivation on Kheda District of Gujarat, Income Rs. 9.00 lacs

Name of Innovative farmer	:	Parsotambhai V.Patel (Mo. 9426386550)
Village & Taluka	:	Gothaj, Mehmadavad
Dist.	:	Kheda
Area	:	10.0 ha
Total income	:	9.0 lakh (Rs.0.9 lakh/ha)
Rate	:	Rs. 15000/ Qt.

Successful farmer for Horticulture crop:
High Tech Dutch Rose Farming in Gujarat

Name of Innovative Farmer	:	Narendrabhai N.Patel
Village & Taluka	:	Kosindra, Daskroi
Dist.	:	Ahmedabad
Total cost	:	Rs. 0.81 crore/1st year
Total production	:	20 lakh flowers/year
Selling rate	:	(Rs. 2.50 /flower)
Income	:	50.00 lakh/year
Total income/4years	:	Rs. 2.00 crores
Net income/4 years	:	Rs. 2.00-0.81=1.19 crores
Net income/year	:	Rs. 29.75 lakh

Source: Dr. I R Rathod, formerly Scientist – Agriculture ,
Anand Agricultural University, Anand

BRIDGING GAPS BETWEEN FARMERS

This is the main challenge to development administration. While in the same village with same land and water resources one farmer makes profit – the other has failed crop and commits suicide. This situation can get further aggravated due to un-foreseen climate change, uninformed farmers suffer more and their productivity is affected. These farmers have to move away from conventional farming and adapt new practices. The local level study by NCCSD with Anand Agricultural University of Anand Block Anand District revealed that between average farmers and progressive farmers – there is gap of 25% to 40% in yields.

While progressive farmers adopt climate resilient practices and right input - & the average farmer fails and has less productivity and in unforeseen changes during season becomes most vulnerable.

The major challenge is to reach out to the marginalized farmers who constitute a major number among farmers and provide the solutions for sustainable livelihood. If this can be met successfully – challenge of food Security and Livelihood can be met. The illustration of Anand Block study illustrates this:

The first table gives overall crop situation. This is followed by example of Rice and Pearl Millet similarly in Horticulture and Livestock – one example is given. Overall study NCCSD enumerates details of each crop.

Anand Block, Anand District, Gujarat

Agri. Crop wise Yield Gap

Sr No	Crop	Area (ha)	Average yield (qt/ha)	Optimum yield (qt/ha)	Yield gap (qt/ha)
1	Pearl millet (K)	3640	15.25	20.25	-5.00
2	Pearl millet (S)	8751	26.78	30.65	-3.87
3	Rice (K)	6230	28.10	35.60	-7.50
4	Wheat	3540	28.00	34.50	-6.50
5	Tobacco (B)	10612	20.00	25.62	-5.62
6	Castor	745	26.00	30.00	-4.00
7	Pigeon pea	205	10.00	15.24	-5.24
8	Sesamum (K)	210	4.60	7.00	-2.40
9	Sesamum (S)	360	7.00	8.50	-1.50
10	Cotton	927	6.57	13.19	-6.62
11	Green gram (S)	289	4.25	7.00	-2.75
12	Chickpea (G)	72	15.00	20.60	-5.60
13	Chickpea (V)	150	18.00	22.00	-4.00
14	Groundnut (S)	100	17.45	23.00	-5.55
15	Mustard	426	14.20	18.90	-4.70
16	Cluster bean (Gum)	431	10.00	15.65	-5.65
	Total	31113			

Source : Agriculture Production Local Level Plan
Shekh & Shelat - NCCSD 2013

Forage Crops : Gaps in Yield

Sr. No	Crop	Area (ha)	Average yield (qt/ha)	Optimum yield (qt/ha)	Yield gap (qt/ ha)
1	Hybrid Napier grass (7 to 8 cuts)	702	2000	2800	-800
2	Maize African tall	1986	600	1200	-600
3	Forage sorghum	2255	650	800	-150
4	Cowpea (Chola)	80	300	400	-100
5	Lucerne (8 to 10 cuts)	737	750	1000	-250
6	Oats (2 cuts)	50	450	550	-100
	Total	5810			

Horticulture Crops : Gaps in Yield

Sr No	Crop	Area (ha)	Average yield (qt/ha)	Opti-mum yield (qt/ha)	Yield gap (qt/ ha)
1	Banana	3120	600	700	-100
2	Papaya	60	415	650	-245
3	Lemon	180	100	120	-20
4	Chiku	60	80	120	-40
5	Ber	30	90	150	-60
6	Pomegranate	25	65	80	-15
7	Aonla	100	90	125	-35
8	Mango	350	45	85	-30
9	Jamun	25	7	10	-3
10	Watermelon	90	460	520	-60
11	Muskmelon	80	300	375	-75
	Total	4120			

Yield Gap in Productivity of Livestock

Sr No	Livestock	Population	Average production	Optimum production	Yield Gap
1	Buffaloes	67285	4.24 lit /day	10 lit/day	-5.6 lit./day
2	Cross bred cows	10000	8.15 lit/day	15 lit/day	-11.85 lit./day
3	Indigenous cow	13852	4.23 lit/day	8 lit/day	-3.77 lit./day
4	Desi layers / annum	10158	130 no./year	180 no./ year	-50 no./ year
5	Improved layer/ annum	427100	250 no./year	300 no./ year	-50 no./ year
6	Broiler	130000	2.00 kg/birds	3.5 kg/birds	-1.5 kg/ birds
7	Emu farming	1500	8.00 eggs/ bird	12.00 eggs/ bird	-4.00 eggs/ bird
8	Fisheries (86 ponds) + Chestnut/ Singoda	267 (ha) 267 (ha)	60000.00 (Net income in Rs) Rs70,000	90000.00 (Net income in Rs) Rs 1,20,000	- Rs 30,000 - Rs 50,000

Example – 1

Major reasons for gap in productivity and action required to be taken

Rice		
Sr. No.	**Reasons for gap**	**Action to be required**
1	Not followed proper time of transplanting and age of seedling	Transplanting should be carried out during 1st fortnight of July by using 25-30 days old seedlings .
2	Plant population is not maintained	Maintain optimum plant population *i.e.* 30 – 33 plant/ sq.m.
3	Use of imbalanced plant nutrients	Adopt INM i.e. use green manure/vermi -compost/bio fertilizer + 120 kg N + 25 kg P +25 kg $ZnSO_4$/ha.
4	Poor adoption of plant protection measure and weed management	Adopt IPM and IWM schedule .
5	Problem of lodging at harvesting stage in *kharif* .	Use of dwarf variety and avoid excess use of nitrogen and water.
6	Lack of timely field operations	Field mechanization should be encouraged.
7	Low water use efficiency	SRI technique and micro irrigation should be adopted.

Example – 2

Pearl millet		
Sr. No.	**Reasons for gap**	**Action to be required**
1	Imbalance use of chemical fertilizer i.e. higher use of N fertilizer as compared to P & K fertilizers	Follow INM to improve soil fertility and productivity.
2	Low water and fertilizer use efficiency	Improve water and fertilizer use efficiency through the efficient farm management and micro irrigation system.
3	Plant density cannot be maintained properly as per recommendation	Optimum plant density should be maintained with appropriate seed rate.
4	Poor adoption of plant protection measures and weed management	Adopt integrated IPM and IWM schedule .
5	Problem of lodging at harvesting stage in *khari*f	Carry out earthing up operation at 35 DAS.

Example – 3

Major reasons for gap in productivity and action required to be taken

Forage sorghum		
Sr. No.	**Reason for gap**	**Action required to be taken**
1	Only local varieties grown	Use HYVs. and improved recommended varieties.
2	Poor adaptation of package of practices	Adopt good agricultural practice, *i.e.,* select fertile soil, use organic manures, and adopt INM and IPM.

Example – 4

Major reasons for gap in productivity and action required to be taken

Banana		
Sr. No.	**Reason for gap**	**Action required to be taken**
1	Use of local seed materials	Use tissue culture plant of Robusta & Grand-9.
2	Use of imbalanced nutrients	Apply fertilizer on STV basis and adopt INM. Apply RDF *i.e.* 250-250-125 kg NPK/ha.
3	Flood irrigation method	Use micro irrigation system *i.e*. drip.
4	Lodging of banana at ripening stage	Grow wind break crops like Sesbania / Shevari, Earthing up and provide bamboo support.

Example – 5

Major reasons for gap in productivity and action required to be taken

Milch Animals		
Sr. No.	**Reason For Gap**	**Action to be required**
1	Poor performance of non-descript indigenous breeds	Select the high yielding animals and cross breeding .
2	Lack of awareness about feeding of mineral mixture to the animals	Feed recommended mineral mixture to the animals.
3	Insufficient fodder	Grow green forage around the year as per requirement.
4	Farmers are not aware of the latest scientific technologies in livestock production and management	Follow latest scientific technologies in livestock management.
5	Poor housing and management	Keep animals in protective shelter with good sanitation and aeration.

These gaps in productivity are at local level and hence can be bridged easily. What is needed to identify them. Advise farmers about corrective action needed and follow up to bridge them. If this is done by extension team the productivity and production can enhance by 20% to 25% in a very short terms. This is the challenge to Agriculture Extension Administration.

DEVELOPMENT OF SUSTAINABLE FOOD VALUE CHAIN FOR CLIMATE SMART AGRICULTURE

- This is key to sustain agriculture and increase income of farmers despite adverse effect of climate change
- World over demand for food products, dairy products – meat is growing and will increasingly grow due to increased urbanization and growing middle class.
- The gap lies - in linking the farm products; from farm to processing / packaging and ultimately to final retail outlet –
  - Adverse weather impact – heat stress, spoil food/ vegetable/ fruits/ milk creates losses in transit which about upto 25%
  - The middle man makes huge money who offers not only low price but also further takes cut of an average of 5% for storage losses.

Hence, a well managed food value chain is pre-requisite for sustainable livelihood. This includes-

- Input supply
- Grading, sorting, packaging
- Storage – silos
- Processing
- Distribution
- Market price information and need / information on demand of quality and quantity of products
- Actual marketing – wholesale – retail outlet – inter linking of

This involves -

- Public –Private partnership with farmers, with focus on small holder who are more than 80% of total farmers, with initiative and follow up from government and civil society and agri. marketing organisation.

- Linking of farms – farmers with successive value addition action. Raw agriculture materials in to food products that finely reach final consumer. This should be in a manner that is profitable to all stakeholder in chain but with focus on farmer who should not be looser or exploited. Already a good marketing network exists through Agricultural Produce Marketing Committee (APMC) and producers – cooperative dairy network- following needs attention

Farmers waste agri produce because -

- Harvesting time :
  - It needs to change during warmer period - only morning
  - Not during rain
  - Prefer late afternoon or early morning.
- Handling after harvest - protection from sunlight and rain and bulk transfer of harvested produce with care
- Storage methods move – from broken bags with holes to tin or plastic containers.
- Prevention methods – application of rodenticide – to manage rat menace
- Grading – sorting – packaging methods to increase value of products

This is due to -

a) Insufficient knowledge about the methods by which harvested produce can be better handled

b) Insufficient income to have storage capacity

c) Limited market access due to lack of information and knowledge about demand, price and of place where prices are higher and means by which they can sell their products at markets where prices are high

Solution lies by educating, communicating and through capacity building to farmers about

- Cleaning
- Sorting
- Grading
- Packaging
- Better methods of harvesting and bulk transport from farm to home/ market yard/ware-house

- Using improved equipments for thrashing and drying
- Storage - in proper container like crates for fruits and eggs, bulk cooler for milk
- Transport system - allowing bulk transport of agri produce through public transport – like buses and trains and promote young persons to run mini transport vans.
- Information to farmers on market price, alternate markets and even direct sales to consumer and of demand for products both its quality and quantity
- Educating farmers about value loss – they make due to careless managing and providing guidance and support on how they can increase income by being little more careful.

Fruit & Vegetables

Market

The Illustrative guidance -Mango

- India is the largest producer of mango and pomegranates.
- Most of the production is consumed locally.
- There is great potential to export and, especially, to reach the growing high-end domestic market.
- Gujarat is the third largest fruit producing state of India. Renowned for its Hafoos (Alphonso) and Kesar mangos, the state contributes much more to the national fruit production.
- The state accounts for 10% of fruits produced in India, and is in third position in state-wise production, after Andhra Pradesh and Maharashtra.
- Gujarat not only supplies the national and local markets but even exports fruit. Though the rate of export from the state is low compared to other states, Gujarat is catching up. Gujarat exports mango, pomegranate and banana.

Challenges in Gujarat Fruit Market

- What challenges does the Gujarat fruit supply chain face?

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by Anne Del, Castillo-FAMU

- Small/marginal farmers
- Significant post-harvest losses
- Cost of certifications
- Fragmentation
- Absence of economies of scale
- Low level of processing/value addition
- Inadequate market infrastructure
- Difficulties to access timely and accurate market information
- Legal barriers

How is Fresh Fruit Sold in Gujarat?

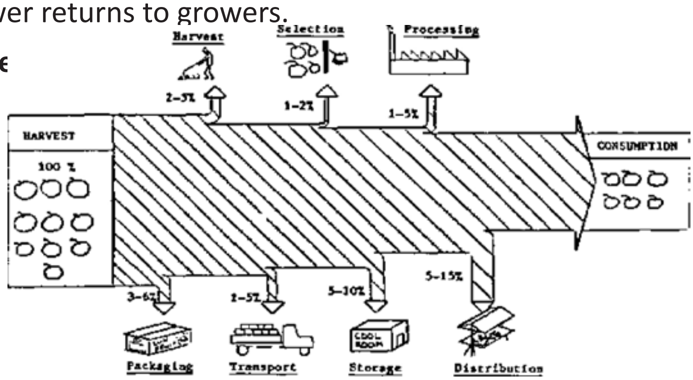
- Farmers are indebted to village moneylenders, traders or landlords. They are often forced either to enter into advanced sale contracts or sell the produce to them at low prices.
- Some villages are still not connected by roads. Adequate transport means are not available even in villages connected by roads. It is difficult to carry the produce in bullock or camel carts to markets, which are often situated at long distances.
- There is only a small quantity of marketable surplus with a majority of the farmers because of the small size of holdings.
- Farmers are hard-pressed for money to meet their social and other: obligations, and are often forced to sell their produce right in the villages.
- Most of the perishable products need to be marketed in the villages because of their low "keeping" quality and the non-availability of quick transport means.
- Many farmers dislike city markets mainly because of their lack of knowledge about prevailing market practices, the possibility of theft or robbery in transit and problems faced by them for selling their produce in city markets.
- The information on the prices prevailing in the nearby primary and secondary wholesale markets is not readily available to the farmers.

As a Result

- Many players in horticultural produce supply chain, including the input suppliers, the farmers, traders, post-harvest contractor/aggregators, commission agents, wholesalers, retailers and the final consumers.

- Multiple intermediaries and handling, leads to:
  - high physical wastage;
  - value loss of the produce and
  - lower returns to growers.

Ine **ue**




An Efficient Supply Chain

Organizes activities across the supply chain to:

1. create value for consumers and
2. increase the profitability of every link in the supply chain; and
3. integrate the process of producing value for the end user or ultimate consumer.

Two Options for a Better Market

- Producer Cooperatives
- Contract Farming

Sell your Farm Produce at APMC:

Farmers need to be careful about where they are selling their produce. A case study by Shri Malay Joshi – VRTI reveal that if a farmer sells his cotton directly to ginning factory – rather than to local trader, he can get 25% higher price. Similarly Rs.2300/- at factory, Rs.1500/- by traders [Nagalpur Village, Mandvi – Kutch]. There are occasions when market price is low – at that time farmer need to sell his produce to procurement centre of govt. where they are getting minimum support price but farmer who do not sell their produce at MSP (Minimum Support Price) procurement centre loose about 10 per cent to 25 per cent in price. That much their income is lost. Hence be sure sell the produce to APMC. But if price is low, sell it to Govt. Procurement Centre – but do not get in easy way of selling to local trader and loose money and learn to hold your produce – be not in hurry to dispose it off – once it is harvested.

In order to get higher value farmers must organize in a group and book a transport and go to APMC to sell their produce. There is need to keep track of price which is published daily by newspapers and go to APMC when prices are higher. Initially once harvesting seasons start, with more supply, prices tend to be low. Hence need to wait till they go up.

NON FORMAL EDUCATION CENTER AT VRTI MANDVI-KACHCHH

This centre is promoted By VRTI (Vivekananda Research and Training Institute, FAMU(Florida Agriculture & Mechanical University) and NCCSD. VRTI is the Executing Organization.

The Following pages presents the technical Guidance developed by US Team from FAMU.

The centre is working under overall Supervision of Shri Ashvinbhai Shroff Chairman VRTI and Excel Industries Shri Malay Joshi is the Principal. His Email ID is malaykutch@gmail.com.

VISION STATEMENT

Says Shri Kantisen Shroff:-

In arena of changing climate a one stop Non formal Education Centre to serve local, regional, national and global farmers is need of time to provide them with solutions for different climate resilient agriculture practices at local level.

MISSION STATEMENT

The Center will build the capacity of farmers in the area of climate resilient agriculture, through knowledge sharing and "hands-on" training, by helping farmers to sustain farm productivity under adverse climatic conditions; and by helping them to increase productivity and profit.

RESOURCES

- **Training Facilities:**
  - o Mandvi campus: Training hall with multimedia facilities, capacity – 100 trainees, hostel for trainees – capacity of 30 trainees
  - o Naliya campus: Training hall with multimedia facilities, capacity – 70 trainees

- **Soil & Water testing laboratory:**
    - o A laboratory equipped with instruments and other facilities to conduct basic analysis of soil samples and water samples with reference to agriculture related guidance
- **Demonstration Farm:**
    - o 5 acre model farm at Mandvi campus with proper fencing. A site for different field related demonstration, technology demonstration and cropping system demonstration. Another farm of 4 acre size has been selected to carry out different demonstration related to climate smart agriculture practice.
- **Training Faculties:**

Dr. S K Kundu	Mr. M L Baraiya	Mr. Malay Joshi
Dr. Kirit Shelat	Dr. Ramanbhai Patel	Dr. Rohit Srivastav
Mr. S K Paregi	J S Gosalia	Dr. I R Rathod

- **Visiting US Scientists:**

Dr. Shaikh	Dr. Verian D. Thomas	Mr. Trevor Hylton
Dr. Amita Jain	Dr. O.S. Mbuya	Ms. Velma Gwishiri
Dr. Kamal Hyder	Les Harrison	Jorge Luis Montezuma
Dr. Gilbert Queely	Mr. Chester Bunker	Mr. Glyen Holmes
Dr. Nathan Bailey	Anne Del, Castillo	

Stakeholders:

- Vivekanand Research & Training Institute
- Florida Agriculture & Mechanical University-FAMU,USA
- National Council for Climate Change & Sustainable Development (NCCSD)
- Agriculture Department, Government of Gujarat
- Agricultural Technology Management Agency-ATMA
- Anand Agricultural University, Anand
- Junagadh Agricultural University, Junagadh
- Sardarkrushinagar Dantiwada Agricultural university-Dantiwada
- Indian Council of Agricultural Research (ICAR)

Building for Non formal education center:

The journey so far:

- Since January 2017, 13 volunteers from Florida A & M University have provided technical assistance to carry out capacity building programmes for farmers and trainers. Total 2,845 farmers (1,872 male & 973 female) were trained. During these sessions, 50 farmers of Kachchh district were selected for 'Training of Trainer (TOT)' role and these farmers had attended all training sessions. They are now guiding other farmers to develop climate smart agriculture.
- Based on these training progrmmes, learning material for farmers has been developed in local language and distributed among farmers.
- VRTI is also running 'Farm Clinic' at the campus where farmers who come for guidance for different agriculture related issues are properly guided and they are also directed to visit model farms in surrounding area (TOT) farmers.

MANAGEMENT OF SALINE SOILS AND WATER

Introduction

Salinity in Gujarat State is due to the following main three ways: i) intrusion of tidal water along the coastal line areas and ingress of sea water, ii) inland salinity due to drought in arid and semi-arid regions, and iii) salinity due to irrigation, irrigation with saline water, poor management of canal, tributaries and farm water courses in addition to poor agronomic water management practices adopted by the farmers.

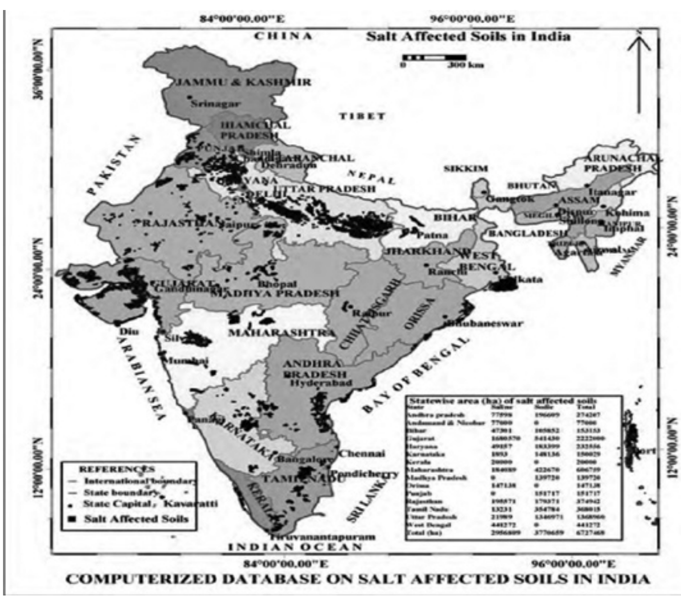


Figure 1. Salt affected soils in Gujarat and other regions of India

Soil salinity and alkalinity are acute agricultural problems in Gujarat because the State is bestowed with 1600 km long coastal belt and large low lying coastal area. Huge coastal area and interior parts of the cultivated land become salt

By Dr O. S. Mbuya, Dr Amit Jain with Dr I R Rathod affected due to intrusion of tidal water and ingress of sea water. Examples of coastal salinity areas in Gujarat State are Dandi, Upbharat, Hansot, Kambhat, Bhavnagar, Jamnagar, Veerawal, Mandvi, Kuchchh and Bhuj.

Similarly, development of inland salinity also plays an important role in agricultural production, where high temperature and high evaporation create problems of upward movement of salts which accumulate on the soil surface. This type of soil salinity is due to the weathering and dissolution of underlying salt bearing parental material (rock). Inland salinity problems in Gujarat are common in Harij, Chansma, Santalpur, Deodar, Khara Ghoda, Viramgam, parts of Surendranagar district and Hasot.

Salinity development in command area in Gujarat State is also a burning issue for transforming salt affected soil. Salinity in command areas like Ukai – Kakrapar, Daman Ganga (in south Gujarat), and Mahi, Kadana and Narmda (in middle Gujarat) are acute due to poor management as mentioned below.

Reasons for salinity development in command areas:

- Poor drainage of sub soil.
- Insufficient provision of drainage system in command area.
- High intensity of irrigated agriculture.
- Heavy seepage losses from the unlined canals, distributaries and farm water courses.
- Enclosing irrigated fields with embankments and choking up natural drainage.
- Blocking of natural drainage by roads and railways.

Definitions of Salt Affected Soils:

Salt affected soils may contain - excess soluble salts and excess exchangeable sodium.

There are three classifications of soil salinity (saline soils, sodic soils and saline-sodic soils):

Saline soils

- Soils with electrical conductivity (EC) greater than 4 decisiemens per meter (dS m^{-1}), equivalent to millimhos per centimetres (mmho cm^{-1}).
- pH is generally below 8.5.

- Leaching salts from saline soils will not increase the pH.
- Salinity is a measure of the total amount of soluble salts in soil.
- Salts generally found in saline soils include:
    - Sodium chloride
    - Calcium chloride
- Gypsum (CaSO4) Magnesium sulphate ($MgSO_4$)
- Soluble salts contained in saline soils include ions of:
    - Sodium (Na^+),
    - Potassium (K^+),
    - Calcium (Ca^{2+}), and
    - Magnesium (Mg^{2+})
- Along with the following anions, chloride (Cl^-), sulphate (SO_4^{2-}), nitrate (NO_3^-), bicarbonate (HCO_3^-) and carbonate (CO_3^{2-})

Figure 2 : Crack formation and white patches observed on saline soil

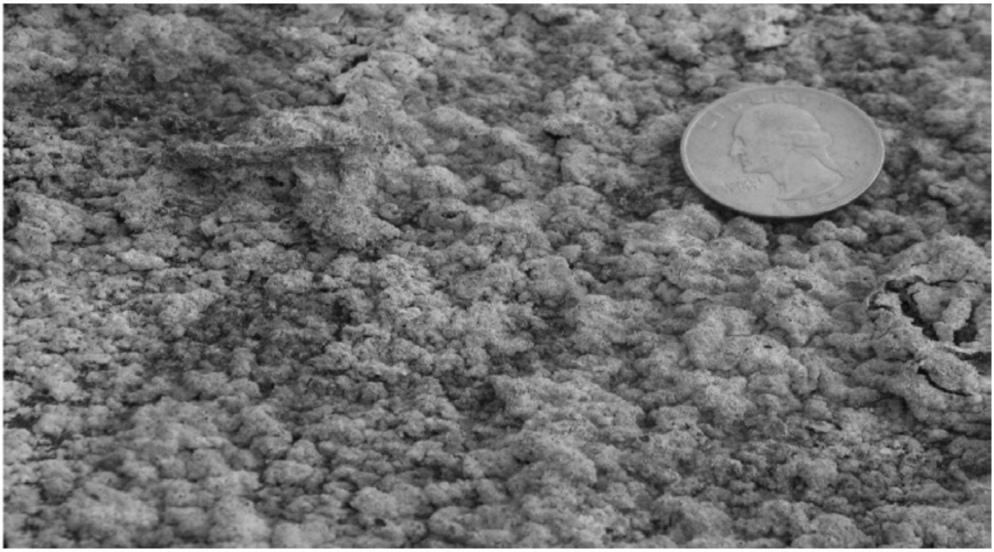


Figure 3 : White powder observed of salt on surface of saline soil

Sodic Soils

- Sodic soils are low in soluble salts, but relatively high in exchangeable sodium (ESP)
- Sodic soils are unsuitable for many plants because of their high sodium concentration.
- Sodic soils have high pH (8.5 to 12.0)
- High sodium levels disrupts both the chemical and physical composition of soil clays (e.g. soil structure).
- Sodic soils have low permeability to air and water (rain and irrigation)

Saline-sodic soils

- Have significantly higher concentrations of sodium salts relative to calcium and magnesium salts
- Have EC < 4 mmho cm^{-1} and a pH < 8.5 and the ESP > 15
- pH (-log $[H^+]$) is generally below 8.5 (desired pH range is 6.0 to 7.0).
- Leaching salts from saline soils will not increase the pH

Measurements of Soil Salinity

- **Electrical Conductivity (EC)**
  - Measures the ability of soil solution to conduct electricity (expressed in $dS\ m^{-1}$)
- **Total Soluble Salts (TSS)**
  - Total amount of soluble salts in a soil-saturated paste extract (expressed in $mg\ L^{-1}$ or ppm)
  - There is a linear relationship between TSS and EC
  - TSS = EC x 640

Management Practices Advocated for Salt Affected Soils:

Management of Saline Soils

A. Preventive Measures:

- Prevent the ingress of sea water and intrusion of tidal water nearby the adjoining low lying area of sea shore by means of constructing dyke, pakka wall, bunding, which can restrict the spreading of tidal water in the interior part nearby the sea shore.

Figure 4. Plantation of mangrove on the sea shore area to prevent the sea water in cultivated land

Figure 5 : Prevent intrusion of tidal water in cultivated land nearby sea shore and conserve the rain water by bunding

- Planting of trees like bamboos with strip cropping system / pattern around the fields to break the speed of the wind and to protect the field with wind erosion.
- Growing of salt tolerant crops like paddy, wheat, sugar beet, mustard, barley and grasses like –Gatton panic, Burmunda grass, Congress grass, Hybrid napiear grass and trees like Mangrove, Nilgiri, Saru, Subabul, Vilayati babul [Prosophis julyflora], bamboo, etc., which can facilitate to improve the physical, chemical and biological rejuvenation properties of the salt affected soils.

Figure 6 : Bamboo and Eucalyptus plantation and grass cultivation in salt affected soils.

Figure 7. Salt tolerant horticulture crop, Date palm variety Barahee

Figure 8. Ber plantation in salt affected soils

B. Control Measures:

The following agronomic practices are advocated for management of salt affected soils:

Crop residues

- Incorporate crop residues into the soil to increase soil organic matter (e.g. use of green manure and animal manure). Increased soil organic matter improves soil structure, drainage and aeration.

Figure 9. Green manuring of Sesbania crop in salt affected soil

Minimum tillage

- Minimum tillage improves soil structures, and in turn improves drainage. Excessive tillage of soils promotes formation of a hard pan below the soil surface (about 0.5 to 1 m deep), causing poor soil drainage.

Figure 10. Broad bed and furrow system of land configuration in salt affected soil

Water Management:

- **Use of irrigation:**
  - Canal – Tube well – In absence of that through water harvesting – water-shed management and even – storing rain water in farm ponds. Irrigate the crop at critical stages of irrigation when there is a low availability of irrigation water. Adopt the micro-irrigation system like drip irrigation system with mulching practices.

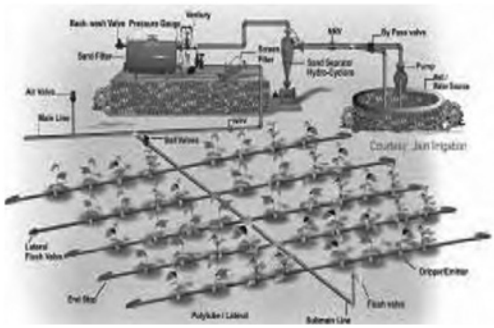


Figure 11. Use of improved method of irrigation (left: drip irrigation; right: sprinkler irrigation)

Soil drainage

a. Make sure that the soil is properly drained to make leaching (washing out) of excess salts possible.

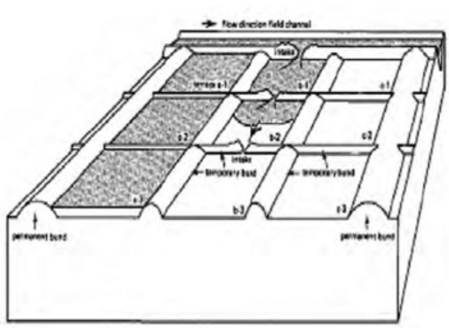


Figure 12. Provision of drainage system to reduce soil salinity

Use of mulch:

- Evaporation of water from saline soils increases the amount of salts on the soil surface
- Any practice that will minimize evaporation will help mitigation (or reduce)of soil salinity.

The practices of mulching reduce the evaporation rate and prevent the accumulation of salts from the deep layer of soil on the surface. It can moderate the soil temperature and maintain the soil moisture at optimum level. It can also reduce the infestation of weeds, pests and soil borne diseases.

Figure 13. Use of organic mulch (e.g. crop residues) to reduce evaporation:

When soil dry-up in post monsoon season salt has a tendency to reappear on the surface due to upward capillary movement of water. Central Soil Salinity Research Institute, Kernal Studies the effect of rice husk as mulch with or without application of gypsum. It was found that paddy husk mulching checked evaporation from soil surface and prevented upward movement of salts. The yield of paddy increased with increasing depth of rice husk, applied as mulch in plots where no gypsum has been applied.

a) **Use of inorganic mulch i.e.** use of plastic mulching.

Application of soil amendments:

- Proper and frequent soil testing is required to determine the type and amount of soil amendment needed.
- Use recent/current soil test data to determine the type and amount of amendment to be used
- Use of fertilizer and fertilizer management should be part of soil management strategy

Restoration of saline-alkali and alkali soils for growing crops demands that physical properties of soils are improved and excess salts are removed out of root zone. Also Sodium present in complex of clay must be replaced by clay calcium, which is essential for good structured soils and is an essential plant nutrient.

a) Calcium is generally added as gypsum. Gypsum – $CaSo4$ is comparatively cheaper than other sources of calcium. Applied the gypsum on the basis of soil analysis report.

b) Adopt the heavy green manuring practices of sesbania crop and incorporate bio mass of sesbania when optimum moisture level (nearly 40 – 45% moisture) available in the soil. Apply the single super phosphate @ 50 kg per hectare for proper decaying of bio mass of sesbania crop.

Use of micro-nutrients:

Experiments at the Central Soil Salinity Research Institute, Kernal have shown that in addition to N,P and K, it is extremely essential to add zinc to these soils. Increased yields to the extent of 20 q/ha of paddy have been obtained by application of $ZnSO4$ - zinc sulphate at the rate of 45 kg/ha. Zinc sulphate is applied along with other fertilizers by broadcast before transplanting. In subsequent years the dose may be reduced to 25 kg/ha.

Alternative crops

- Plant alternative crops that are tolerant (less susceptible) to soil salinity

Crop rotation

- Continuous cultivation of one crop could exacerbate soil salinity
- A planned crop rotation could be an alternative of controlling soil salinity
- Crops with different rooting depth and salinity tolerance

Plant breeding and bio-technology

a. Identify plants that are tolerant to soil salinity and cross breed them with high yielding susceptible plants.

b. Identify genes that make plants tolerant to soil salinity and introduce them to agricultural crops

Selection of suitable crops, crop rotations, method of planting and plant population are very important considerations in reclamation of saline soils and cropping patterns thereafter. During the initial stages of reclamation only salt tolerant crops are taken and as the soils improve sensitive crops can be grown. Adopt the following crop sequences in salt affected soils:

Salt tolerant crop	Medium salt tolerant crop	Sensitive crops
Field crops:	**Field crops:**	**Field crops:**
Paddy, Barley, cotton, wheat, mustard, Sesbania, sugarbeet, sugarcane	Oat, paddy, sorghum, millets, maize, gram, cotton, Lucerne	Field been, cow pea, etc.
Horticultural crops:	**Horticultural crops:**	**Horticultural crops:**
Date palm, coconut, mangrove, saru, eucalyptus, sisu, acacia, etc.	Pomegranate, grapes, mango, guava, banana, pich, apple, grape fruit etc.	Nil
Forage crops:	**Forage crops:**	**Forage crops:**
Gatton panik, burmunda, hybrid napier, sudia jovar	Berseem, Lucerne, gatton panik	Nil
Vegetable crops:	**Vegetable crops:**	**Vegetable crops:**
Turnip, spinach, beet root, carrot, garlic, onion etc.	Tomato, bottle gourd, garlic, carrot, beet root etc.	Nil

Selection of crop resistant to saline sodic soil/salt affected soils:

Selection of suitable crops, crop rotations and plant population are very important consideration in reclamation of these soil. During the initial stages of reclamation only salt tolerant crop are taken and afterwards as the soils improves even sensitive crops can be grown.

Crops and varieties:

Paddy transplanted: Jaya, Dandi, GR-3, Masuri, SLR-51214 and IET-14096, Jhone-34, JR-68

Wheat:	Kalyan sona, Arnej – 207, HD – 2009, J-24
Cotton:	Gauch – 7, G-cot – 21, Kalyan
Sugarcane:	Co – 8338, Co-791 – Co-671
Castor:	Gauch – 1, SKI – 73, VP-1
Groundnut:	JL-24, J-11, TG-32, TG-26, Robert
Saff flower:	Ic – 11839, Tara, Bhima
Sorghum:	Gundari, CSH-5, C-10-2
Millets:	GHB – 235, BK – 560, GHB - 105
Barley:	C-164
Berseem:	Mescavi local
Sugar beet:	Mariboresista poly

Green manure crop: sesbania is recommended as best green manure crop for biological rejuvenation of salt affected soil. It can improve the chemical, physical and biological properties of the soil because it can incorporate maximum bio mass in the soil and it improves the soil pH, EC and ESP of the soil to a greater extend.

The best cropping pattern for saline-sodic soils may be sesbania [G.M.] – Paddy – Wheat / Berseem / Sugarbeet.

Importance of quality of irrigation water for crop production:

- Water quality is a concern for everyone who uses water for any purpose.
- Irrigation water quality can affect soil's health and its long term productivity
- Irrigation water quality can also directly affect plant development and growth.
- Knowledge of irrigation water quality is critical for managing the quality and productivity of a crop.

Irrigation Water Quality Criteria:

1. Salinity – total soluble salt content
2. Sodium – relative proportion of sodium to calcium and magnesium ions

3. pH and Alkalinity – carbonate and bicarbonate
4. Specific ions – Chloride, boron

Criteria to determine the quality of irrigation water:

The following characteristics of water are most important in determining quality of irrigation water.

1. **Salinity hazards** - Total concentration of soluble salts.
2. **Sodium hazards** - Relative concentration of Na^+ to other cations.
3. **RSC hazards** - Bicarbonate concentration as related to Ca^{2+} and Mg^{2+}.
4. **Boron hazards** - Concentration of boron.
5. **Other hazards** - Toxic effects of certain constituents.

1) **Salinity hazards** - Total soluble salt concentration:

Total soluble salt (TCS) concentration of irrigation water is expressed as electrical conductivity (EC) millimhos/cm or dSm^{-1}. Water with high salt content is known as saline water. The salinity of the soil ultimately depends on the amount and kind of salt carried by irrigation water and that accumulated in the soil.

2) Rating of salinity hazard on the basis of electrical conductivity:

EC	Low	Medium	High	Very High
Millimhos/cm	< 250	250-750	750-2250	>2250

If total soluble salts (TSS) are very low, usually no need to determine ionic content but if high, other criteria besides TSS are needed.

Irrigation Water Classification and General Salinity Hazard

Classes of water	**EC ms/cm**	**Salinity hazard & Management Techniques**
Cl.1, Excellent	<0.25	None
Cl.2, Good	0.25-0.75	Water is suitable for growing most crops under most conditions

Cl.3, Fair	0.75-2.0	Water can be used successfully for most of the crops if care is taken to prevent salt accumulation. Good irrigation and drainage and leaching must be practiced.
Cl.4, Poor	2.0-3.0	Use of water is restricted to well-drained soils for production of salt tolerant crops.
Cl.5, Unsuitable	>3.0	Unsuitable for irrigation, except for very high salt-tolerant plants. Excellent drainage, frequent leaching, intensive management required.

SALINITY

- Salinity – total amount of dissolved salts
  - – Total Dissolved Solids (TDS) : mg/L or ppm
  - – Electrical Conductivity (ECw)

    1mS/cm = 1 mmhos/cm = 1dS/m

    640 mg/L TDS = 1 mS/cm EC

Determination of Total Dissolved Solids

- The direct and accurate method of determining TDS is to heat a known volume of water to dryness and weighing the residual solids.
- The results are reported as mg of solids/L of water
- The higher the TDS, the higher the salinity of the water.

Managing Irrigation Water with High in Salinity level:

- Frequent Irrigation, Soil Leaching, and good Drainage
- Minimize contact with plant leaves
- Plant salt-tolerant crops - Barley, Wheat, sugarbeet etc.
- Avoid saline water irrigation to seedlings and young plants
- Dilute high saline water with low saline water

Sodium Hazard of the Water

SAR Values	Sodium hazard	Comments
1-10	Low	Avoid highly sensitive crops
10-18	Medium	Amendment and leaching needed
18-26	High	Unsuitable for continuous use
>26	Very High	Unsuitable for irrigation

Adverse effect of Sodium on Soil and Plant:

Soil

- Dispersion, sealing of soil pores, reduced water infiltration
- Lower hydraulic conductivity
- High Na^+ conc. can induce Ca and/or Mg deficiency
- Nutrient uptake interferences

Plant

- Stunted plants
- Toxicity and leaf burn potential

Managing Irrigation Water High in Sodium Concentration

- Apply a source of soluble calcium to reduce sodium-related permeability problems
- Acidify the irrigation water with sulfuric acid
- Mixing with alternate source of water
- Frequent Irrigation
- Growing tolerant crops
- Organic matter application

pH

- pH is measured on a scale of 0-14
- pH of 7 – neutral; <7- Acidic; >7 – basic
- pH range for irrigation water is 6.5 – 8.2

- High pH > 8.2, the potential for sodium hazard increases due to high carbonate and bicarbonate concentrations and formation of insoluble precipitates.

ALKALINITY

- Alkalinity is a measure of dissolved substances in water that can buffer or neutralize acids.
- Alkalinity buffers the water against sudden change in pH.
- Alkalinity is primarily caused by the presence of bicarbonate and carbonate ions.
- High pH and high alkalinity cause precipitation of calcium and magnesium bicarbonate leaving sodium as the dominant ion.
- Alkaline water can exacerbate sodic soil conditions

Chloride in Irrigation Water

- Essential to plants in very low amounts
- High concentrations cause toxicity to sensitive crops
- Leaf burn potential with sprinkler irrigation and the risk is higher dany day time
- Direct contact of irrigation water with leaf surface should be avoided.

Tolerance of plants to Chloride in irrigation water

Chloride (mg/L)	Effect on Crops	Susceptible Plants
< 70	Safe for all plants except very low tolerant plants	Blueberry, dry beans, Azalea
70-140	May cause injury for low tolerant plants	Onion, carrot, lettuce, grape, mint, pepper, raspberry
141-350	Moderately tolerant plants may show toxicity symptoms	Potato, alfalfa, sqash, wheat, sorghum, corn, tomato
>350	Severe adverse effect	Sugarbeet, barley, asparagus, cauliflower

Managing Irrigation Water High in Chloride Concentration

- Plant a less sensitive crop
- Use furrow, flood or drip irrigation to avoid foliar contact with irrigation water
- After each irrigation event, rinse the plants with high-quality water if available

Boron in Irrigation Water

- An essential element for plant growth and nutrition
- Required in very small amounts

Figure 13. Boron deficiency in maize plants

Figure 14. Boron deficiency in plants

- Toxic to sensitive crops at conc. >1 ppm

Tolerance of plants to boron in irrigation water

Boron (mg/L)	Tolerance level	Susceptible Plants
< 0.5	Extremely sensitive	Blackberry
0.5-0.75	Very Sensitive	Peach, plum, grape
0.76-1.0	Sensitive	Wheat, Barley, Strawberry, lima bean, garlic, onion, walnut
1-2	Moderately sensitive	Pepper, carrot, pea, radish, potato, cucumber
2-4	Moderately tolerant	Lettuce, cabbage, mustard, squash, oats, corn, clover
4-6	Tolerant	Sorghum, tomato, sugarbeet
6-15	Very Tolerant	Asparagus

Technology advocated for management of irrigation water for crop production:

Salt Tolerance

Concentration of EC	Salt tolerance crops rating
Higher EC	Forage Crops / Field Crops
	(Highly salt tolerant crops)
Lower EC	Vegetable Crops / Fruits Crop
	(Highly sensitive crops to salinity)

Management of agronomic practices advocated for quality of irrigation water and crop production in problematic soils:

In problematic soils, irrigation practices or management of irrigation involve the following points:

1. **Analyze the irrigation water before its suitability for irrigation purpose:**
   - Know the quality of irrigation water and its suitability for irrigation purpose.
   - Identify the problems of irrigation water and then use recommended practices / treatments for its applications in the field i.e. saline water, sodic water and water deficiency with specific ion with chloride and boron.
   - The poor quality irrigation water may be either saline or sodic. Such water can be utilized for irrigation considering the following major conditions.
     - ➢ Highly saline water may be suitable in well drained, high textured fertile soil.
     - ➢ Even less saline water may be more harmful for same crop grown on a heavy textured soil with impended drainage.
     - ➢ We should also consider the quality of irrigation water like EC, SAR and chloride contents and boron contents.
     - ➢ Even poor quality of water can be used by adopting certain agronomy practices considering the –
       - Soil type
       - Climate
       - Drainage
       - Crop to be grown in the specific area.

The above mentioned parameters can play important role in deciding the use of quality of irrigation water in agriculture.

2. **Land preparation and tillage method:**

Careful leveling of land is essential for uniform spread of water and downward leaching. High spots should be left out barren if the enough water for irrigation is not available to leach down the salts.

The physical conditions of alkali soil is usually bad. When it is wet puddles and when it is dry, it leaves hard crust on the surface soil. Such type of soil should be tilled with narrow range of moisture content. For better germination, adequate moisture content should be maintained to avoid crust formation.

Period drying in between flooding can assist in improving water infiltration by in breaking sub-soil compact layers for better leaching of salts. Deep ploughing and sub soiling are considered to be helpful in improving physical condition of the soil and in loosening of the compact sub-soil layer necessary for deeper root penetration.

3. **Seed bed preparation and planting techniques:**

Satisfactory germination is a serious and limiting factor in crop-production on saline and alkaline soils. Many crops are susceptible to even low levels of salinity at germination and seedling stage but can tolerate fairly high amount at later stage of growth e.g. sugar beet.

Bed shaping, planting and irrigation techniques can be designed to reduce the salinity hazard around the seed and plant roots. Irrigation with higher depth of water (ponding or flooding) allows more uniform spread of water and is more effective in salinity control, than furrow method of irrigation in which salts get concentrated on ridges.

Salts often accumulated in the top few centimetres of the soil during the non-crop periods. Where high water tables complicate salinity control, fallow ideal land may rapidly accumulate surface salts particularly in hot and arid climates. Under such conditions, both crop germination and yield can be seriously reduced. A heavy pre-sowing irrigation is en essential practice to wash-off the surface salt that will improve germination and early growth. It is made far enough in advance of desired planting date to allow for cultivation & to remove weeds and prepare the seedbeds.

Uniform and optimum plant stand in problematic soils is a limiting factor. Under such type of soils furrow irrigated row crops are of great agronomic importance in agriculture.

It may be advantageous if such type of soils are provided with slight slope to remove excess water and to avoid accumulation of salts.

4. **Irrigation methods and control:**

The methods of irrigation and water control are highly important in controlling salinity because ultimately salts are removed through irrigation water. The methods of irrigation are closely related to planting techniques also.

The principal methods of irrigation especially for problematic soils are –

1. Furrow irrigation
2. Sprinkler
3. Drip system
4. Pitcher irrigation system (Pot irrigation)
5. Flooding (surface method)

Out of these, flooding is most useful techniques in leaching down the salts from the root zone when adequate water is available. Day by day irrigation water becomes scarce, furrow irrigation, sprinkler and drip system getting more importance. In acute shortage of water pitcher irrigated farming also performs better in keeping away the salts from the cropped root zone area.

The time or irrigation frequencies and quantity of water applied for irrigation are also important for germination of crops, seeds and leaching down the salts from the root zone. Thus, control of water is an important factor for minimizing the salinity problems. The salt concentration is increased due to moisture stress, therefore, it requires, frequent and light irrigations.

Suitability of irrigation water (SIW):

The different criteria on individual base or combined with other factor fully satisfied the use of irrigation water to the crops. Because there are some other factors also involve in suitability of irrigation water under specific situation and soil.

Even poor quality of water can be used under certain agronomic practices. Soil type, climate, drainage, crop to be grown are differed from place to place which plays an important role in deciding the water use.

5. **Selection of salt tolerance crops:**

   a. **Highly salt tolerance crop (>5000 ppm salts)**

      Barley, Sesbania, Sugarbeet, Tobacco, Turnip, Mustard, Coltton, Wheat, Sugarcane, Rhode grass, Pinch, Beet root, Date palm, Coconut.

   b. **Semi tolerance crops (2500 – 5000 ppm salts)**

      Oats, rice, sorghum, pearl millet maize, red gram, green gram, sunflower, castor, sesame, linseed, Lucerne, berseem, tomato, cabage, coliflower, carrot, potato, onion, pomegranate, grape, mango, banana, apple, orange, lemon, strawberry.

   c. **Sensitive Crops (<2000 ppm salts):**

      Field beans, gram, guar, green beans.

6. **Use of organic manures and use of green manuring crops:**

   It improves the chemical, physical and biological properties of the salt affected soils. Therefore, sufficient quantity of organic manures should be recommended to get high yield of crops in problematic soils with poor quality of irrigation water.

7. **Gypsum usage along with sodic water irrigation:**

   The adverse effect of physical, chemical of soils imparted due to use of sodic water. It can be mitigated by application of calcium containing amendments.

Figure 15. Agro forestry plantation with the use of sodic water

8. **Use of agro forestry crop for optimal water use in salt affected soils:**

Agro forestry can provide viable underground drainage for salinity control and for checking rise in water table in canal command areas. Agro forestry system comprising eucalyptus, acacia and saru plantation is mostly preferred for plantation in salt affected soils.

Figure 16. Use of salt tolerant grass cultivation in salt affected soils

9. **Cultivation of hybrid grass in highly salt affected soils:**

Growing of grasses like bermuda grass, gatton penic, sudhia jovar are highly salt tolerant grasses cultivated in salt affected soil which can biologically improve the physical, chemical and biological properties of the soil.

Summary

The quality of irrigation water has a considerable impact on growth and yield of a crop. The following best management recommendations can be made for the use of poor quality of water (i.e. use of saline and sodic water). Analyze the irrigation water before its suitability for irrigation purpose.

i) Know the quality of irrigation water and its suitability for irrigation purpose.

ii) Identify the problems of irrigation water and then use recommended practices / treatments for its applications in the field, i.e. saline water, sodic water and water deficiency with specific ion with chloride and boron.

iii) Poor quality of irrigation water, either saline or sodic water can be utilized for irrigation considering the following major conditions.

- ➢ Highly saline water may be suitable in well drained, high textured fertile soil.
- ➢ Which much less saline water may be more harmful for same crop grown on a heavy textured soil with impended drainage.
- ➢ We should also consider the quality of irrigation water like EC, SAR and chloride contents and boron contents.
- ➢ Even poor quality of water can be used by adopting certain agronomy practices considering the –
    - Soil type
    - Climate
    - Drainage
    - Crop to be grown in particular specific area.

The above mentioned parameters can play important role in deciding the use of quality of irrigation water in agriculture.

- The material consists of some technical guidelines. In order to follow them it is advised to take guidance from KVK scientist - when ever there is doubt.

GOOD AGRICULTURAL PRACTICES AND GOOD HANDLING PRACTICES FOR BETTER VALUE OF CROPS

Good Agricultural Practices (GAP)is a voluntary system that is related to practical, efficient on-farm and off-farm processes aimed towards sustainability and equity for small-scale farmers. GAP was introduced by the Food and Agriculture Organization (FAO) and implemented in many agricultural producing countries. Global GAP is one of the well-known GAP standards in the world for pursuing high quality food safety for the agricultural food producer countries. Global GAP standards are widely accepted by international markets such as European Union (EU) and USA markets. However, the strictness and difficulties of the Global GAP standard could not be satisfied for India farmers' Global GAP practical implementation. With standard and framework developed, India could satisfy the demand of international markets for high quality safe food.

As high quality and healthy food are becoming more important, consumers have concerns about the control of food production and demand more information along the food chain. GAP is based on the principles of risk prevention, risk analysis, sustainable agriculture (by means of Integrated Pest Management (IPM) and Integrated Crop Management (ICM)) to continuously improve farming systems. GAP is of utmost importance in protecting consumer health. It requires ensuring safety throughout the food chain. It must be compulsory and transparent and operate not only from the table but also upstream to include suppliers (e.g. fertilizers, plant protection, etc.). Establishing a consumer demand system such as GAP will provide important advantages for countries like India, not only for the domestic market but also export markets. Therefore introducing and expanding GAP in India will provide some advantages to those countries who trade food with India. The main aims of this manuscript are to review existing knowledge regarding GAP at the national and international level, and discuss the implementation of GAP

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in India and to determine the advantages for whole food chain participants. GAP can be very specific to different activities of the food production chain and marketing, for example, comprehensive fertilizer management, integrated pest management, soil health, harvesting, packing and packaging, marketing, etc.

In the United States of America, Good Agricultural Practices (GAP) and Good Handling Practices (GHP) are voluntary audits that verify that fruits and vegetables are produced, packed, handled, and stored as safely as possible to minimize risks of microbial food safety hazards. GAP & GHP audits verify adherence to the recommendations made in the U.S. Food and Drug Administration's Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables and industry recognized food safety practices. In 2015, The USDA Audit Program performed audits in 50 states, Puerto Rico, and Canada, covering over 90 commodities.

Existing GAP followed by farmers	Practices Suggested	Benefits
GAP are not well followed by farmers. Farmers are not well versed onhow to improve productivity and the quality of their produce. Traditional methods result into getting produce graded as low quality and hence low market price.	Four GAP practices advocated: **Clean Soil** • Involves taking steps to reduce soil contamination via manure and vermi-compost. • Improve soil health through use of well decomposed FYM, well prepared composting materials and green manuring. • Mulching practices also help to prevent the infestation of weed, pest and can prevent or minimize soil borne diseases. Mulching	1. It providessafe, hygienically and nutritive food to the consumer. This adds to value of food produce and such the produce gets higher market price.

Existing GAP followed by farmers	Practices Suggested	Benefits
	practices can be adopted with the use of plastic sheetsand crop residues. • Mulching can reduce soil salinity due to reduced evaporation. Evaporation will concentrate salts in the soil. **Clean Water** • Making sure all water used in washing, cooling and processing agricultural produce is potable. • Water used for irrigation and foliar applications must also be tested to ensure it is safe for the intended purpose (e.g. salinity, free of pathogenic bacteria, harmful chemicals, acidic or alkaline). **Clean hands** • The practice of good personal hygiene in the field and while packing.	

Existing GAP followed by farmers	Practices Suggested	Benefits
	• Providing washing facilities. • Maintain hygiene by washing hands. • Provide water tap and tissue paper or towelon the farm to clean and dry the hands. **Clean surfaces** • Ensuring that all packing bins, surfaces, storage areas, and transportation vehicles are properly washed / cleaned and dried on a regular basis. • Clean farm machineries like tractors and equipment free from contamination effect after harvesting or any farm operations.	

1. SoilManagement Practices:		
Existing Soil Management practices followed by farmers	**Soil Management Practices**	**Benefits**
• Soil Management Practices followed by farmers are inadequate. • Farmers have insufficient knowledge about zero tillage and benefits of zero tillage. • Farmers do notapply sufficient quantities of organic manures like FYM, green manuring, use of compost and incorporation of crop residues and use of bio-fertilizer. • Farmers have inadequate knowledge about use of bio-fertilizer and their application in the soil. • Farmers have insufficient knowledge about the use of Azolla (water fern), blue and green green algae in transplanted paddy cultivation.	[A] Reducing soil erosion by wind and water with the following technology: • By using organic and inorganic mulching practices and restoring of soil organic content in the soil: Incorporation of crop residues like paddy straw, paddy husk bran, wheat bhusa, chatting material of cotton sticks and other plants and incorporate with sufficient quantity of FYM and green manuring of crops in the soil. • Use inorganic mulching practices like plastic mulching. • Establish the living hedge/ trees around the boundary of the fields to bring down the speedof wind. • Sowingof crop in the field in	• By preventing soil erosion due to wind and water, that can control the fly away the top soils which is highly enriched with inorganic carbon total nitrogen, available phosphors, potassium with important minerals and full of micro-organisms which can fix the nitrogen from the atmosphere and convert the unavailable form into the available form. Moreover, good microbial activity facilities congenial environment for better aeration in the soil. • By maintaining organic content / organic matter or by providing the soil ideal crop rotation which can be improve the chemical, physical and biological properties of the soil.

Existing Soil Management practices followed by farmers	Soil Management Practices	Benefits
• Use of organic and inorganic mulching practices not practised by the farmers in large area of the state due to inadequate knowledge about the mulching practices. • Crop residues like wheat,bhusha, sugar cane trash, rice bran husk and paddy straw, cotton straware being burnt at present in the field by the farmers due to lack of scientific knowledge.	opposition of wind direction. [B] Application/ incorporation of fertilizer/manure in the soil. • Apply FYM, crop residues, green manuring of crop properly in the soil and it should be well mixed up in the soil. • Apply chemical fertilizer in root zone area of the plant through the drip irrigation system (fertigation) which can increasethe fertilizer use efficiency and reduce the cost of fertilizer. [C] Reduce Soil Compaction to maintain soil structure: Avoid heavy tillage operations like deep ploughing tillage, frequent use of Rotovator and use of heavy machinery for field operations which can affect the soil properties like soil aeration,	• It can alsoincrease the water holding capacity of the soil. Avoid the heavy tillage practices to restore the better nutrient of water availability to the plants for better nutrient of the plant.

Existing Soil Management practices followed by farmers	Soil Management Practices	Benefits
	infiltration, microbial activities, uptake of nutrients, etc., which in turn can reduce plant growth and yield.	

2. Water

Existing Water Management Practices	Advocated Management Practices	Benefits
Existing water management technology following by the farmers. • Integrated water management practices are not being followed by the farmers. • Farmers are not following the improved method of irrigation. • Farmers do not irrigate their cropsatcriticalstageofirrigation because theyhaveinsufficient knowledge about the critical stage of crop growth and water requirement.	• Practice scheduled irrigation with monitoring of plant needs. • Prevent soil salinization by limiting water input to needs. • Avoid crops with high water requirement in a low availability region. • Use mulch to minimize water evaporation from the soil surface. Evaporation will increase soil salinity. • Water should be applied through different methods of irrigation.	• Scheduling of irrigation based on climatological requirement, type of crop (short duration long duration) Shallow rooted crop or deep rooted crop and biological stages of crop growth which monitors the ware requirement of plant. • Advance technology of irrigation system can increase the water and fertilizer use efficiency of the crop. • Drip irrigation system facilitates to apply the liquid fertilizer and

Existing Water Management Practices	Advocated Management Practices	Benefits
• Farmers have not adapted practices of mulching because they do not have sufficient knowledge of application of mulching in Agriculture. • Farmers not utilize sufficient quantity of organic manure like FYM and green manure compost and incorporation of crop residue like straw of paddy and wheat, stick of cotton etc. • Farmers do not have sufficient irrigation facility. Hardly 40-45% area covered under irrigation - 50-60% area under rain fed Condition.	• Use of micro irrigation system [drip and sprinkler] • Ridge and furrow system. • Broad bed and furrow system with mulching practices. • Use good qualityof water for irrigation. It must be analyzed for use. • Select the crop variety as per agro climatic conditions i.e. for irrigated region and rainfed region.	pesticide thus increases the efficiency & reduces the cost of application and leaching loses of fertilizers. It can increase 35 to 45% more irrigation area for cultivation with the same quantity of irrigation water. • Problem of soil salinization can be prevented through the use of mulching practices and suitable methods of planting. • Mulching can maintain the soil health. • Recommended crop rotation system should be followed by the farmers to prevent the loss of waterthrough the transpiration.

3. Livestock Management		
Existing Practices for Animals followed by the farmers	**Practices suggested**	**Benefits**
• Most of the farmers keep their animals nearby the farm and residential area. • Farmers are using indigenous cattle feeds for their residential facility. • Farmers are not providing a balanced feeding practice. • Farmers are not providing pure water around the year to the animals in sufficient quantity. • Proper veterinary services are not provided by the farmers around the year. • Artificial insemination not properly handledby the farmers when animals are in peak/heat period.	**Animals:** • Provide a balanced feeding practice to the animals i.e. green fodder, dry fodder; concentrate feed and mineral mixture as recommended. • Select the animal breed based on climatic conditions e.g. Gir Cow and Jafra badi buffalo can be selected for Saurashtra Region. • Provide better cattle sheds with full ventilation to have congenial environment to the animals. • Timely veterinary services / vaccination should be provided to the animals around the years to maintain good health of the animals. • Provide good quality of drinking water to the animals throughout the year.	1. By adopting scientific management practices, farmers can earn good return from animal husbandry. 2. He can efficiently utilize by-product like dry fodder, hey, straw and green forage as cattle todder and reduce the cost of products.

Existing Practices for Animals followed by the farmers	Practices suggested	Benefits
	• Animals should be washed as and when required.	

4. Crop Management		
Existing crop management practices followed by farmers		**Benefits**
• Farmers have low level of knowledge about the selection and use of crop cultivars and varieties based on local demand of market. • Farmers are not growing varieties and crops cultivars according to recommendation made for the different agro climate zones in Gujarat state. • Farmers are not following the inter-cropping system, advocated by scientists i.e. proper use of leguminous crops. • Farmers have low level of scientific knowledge about the addi-	• Select cultivars and varieties, to meet local consumer and market needs according to their suitability to ill health. Select the crop variety according to the requirements of local markets / consumer. • The variety should be highly responsive to fertilizers. • Inclusion of legumes crop variety to provide the biological fixation of nitrogen from the atmosphere. • Use balance use of organic and inorganic fertilizer to get the	• Recommended variety according to the agro climatic zone, gives higher yield and income to the farmers. • It can compensate the demand of the local markets.

Existing crop management practices followed by farmers		Benefits
tion of organic manures, green manuring and incorporation of crop residues in the soil. They are applying poor qualities of organic matter in the soil and not adopting the balance use of organic and inorganic fertilizer in the soil. • They have poor knowledge about the recycling of crop residue and its importance in the soil. • Farmers are still adopting the indigenous method of rabbing practices afterthe harvesting of crop and not using the proper methods of recycling crop residues. • Farmers are not properly rotating the animal livestock in the fieldsand in pastures to feed the animals.	higher yield of the crop and to maintain the fertility level of the soil.	

5. Integrated pest and disease management (INM) - Crop Protection		
Existing practices followed by the farmers: Disease and Pest Management:		
• Hardly 25-30% of farmers are following seed treatment technology practice and the have poor knowledge about the control of seed and soil born disease. • Farmers have the low level of knowledge about drought and wilt resistance varieties. They have poor knowledge about the use of soil solarization to prevent the soil and seed born disease and to minimize the infestation of weeds. • Only 20-25% farmers are utilizing the Genetically modified and tissue culture plants (i.e. Use of B.T.Cotton seeds, Banana and Pomegranate and Date Palm tissue culture plants because	• Use resistant cultivars and varieties, crop sequences, associations, and cultural practices that maximize biological prevention of pests and diseases. • Maintain balance between pests and beneficial organisms of all crops • Adopt organic control practices where and when applicable; • Determine interventions following consideration of all possible methods and their short- and long-term effects on farm productivity and environmental implications • Promote integrated pest management (IPM); • Store and use agrochemicals separately.	

Existing practices followed by the farmers: Disease and Pest Management:		
farmers have little knowledge about the benefits of Bio technology Plants. • They have low level of knowledge about the planting of trap crop around the field to trap the pest • Mono cropping system and therefore pest and disease cycle cannot be broken down and disease are found in the field. • Farmers have low level of knowledge about the indigenous formulation and use of bio pesticide like -Neem oil, Neem Ark • Farmers are not utilizing the recommended quality & quantities of Organic Manure like use of De-oil cakes, FYM, Green	• Maintain accurate records of agrochemical use. • Ensure that agrochemicals are only applied by specially trained and knowledgeable persons • Ensure that equipment used for the handling and application of agrochemicals complies with established safety and maintenance standards • Maintain accurate records of agrochemical use. • Select the crop variety resistant to pest and diseasesas per recommended for different agro climatic. • Seed treatment given to seeds,transplants or cuttings to prevent or minimize soil and seed borne diseases. Rec-	

Existing practices followed by the farmers: Disease and Pest Management:		
Manure, compost and scientific use of crop residue. • Farmers lacks knowledge to identify proper stage of spraying of pesticides. • Farmers are not applying the recommended doses of pesticides and actualrequired quantities of liquid to be sprayed on the crop per unit area. • Farmers have poor knowledge about the economic threshold levels of different pest infestation.	ommended dose of pesticides should be used for different crops and seasons. • Use optimim quantity of pesticides liquid as per recommendation to get the effective control of pest and diseases.	

6. Harvesting and Harvest Containers and Tools		
Existing harvesting practices and use of containers and tools followed by the farmers in Gujarat state.		
1. Proper hygienic conditions are not being maintained by farmers, i.e. proper hand-wash and use of bins or storing of packaging material. They are not properly maintaining the grading, sorting, processing, packaging and proper transportation facilities of their produce after the harvest. They do not have the ideal facility to store the harvest produce therefore 25-30% losses occurs after harvesting of perishable crops like fruits, vegetables etc.	**Harvesting** • Wash hands before starting to pick. • Reject produce that is damaged or having visible signs of bird droppings. • Do not harvest produce that has fallen on the ground. Otherwise wash it thoroughly with clean water. • Remove as much soil as possible from harvested produce. • Don't let harvested produce remain in the field for a longer period than it is required. **Harvest Containers and Tools:** • Do not put clean produce in a dirty container	By adopting recommended practices identified for harvesting and safe use of containers and tools,farmers can provide better quality of produce and hygienic food to consumers and as a result get better markets and higher prices for their produce.

Existing harvesting practices and use of containers and tools followed by the farmers in Gujarat state.		
	• Choose containers that can be easily cleaned, such as plastic. • Clean containers and tools between uses. • Never use Harvest containers for storing chemicals or as trash containers. • Use separate containers for collecting culls during grading and packing. • During the off-season, store food-contact harvest containers indoors off the floor.	

7. Handling		
Existing handling practices adopted by the farmers		
• Farmers are not following proper management practices /methods for handling of their produce due to lack of knowledge. • Farmers are not using washing detergent and clean water to maintaining hygienic conditions as per required standard. •They are not storing food product under hygienic and appropriate environmental conditions. • They are not adapting recommended practices for packaging of food produce at the farm and while transporting from the farm.	• For washing, use recommended detergents and clean water; • Store food products under hygienic conditions. • Pack food produce for transport from the farm in clean containers; • Use recommended detergents and clean water for washing of the farm produce. • Store food products in hygene conditions.	• By handling the farm produce with recommended practices farmers can get the good market rates for his products and better quality of farm produce available to the consumers.

8. Energy and waste Management		
Existing practices followed by the farmers for utilization of energy and waste management in Gujarat state		
Farmers are not well aware of proper utilization of use of renewable energy in agriculture through the scientific application of wind / solar and bio fuels energy in agriculture due to low level of knowledge among them. Farmers are not practising recycling of organic waste and inorganic material. Farmers are not storing fertilizers and agro chemicals securely due to lack of knowledge and poor conditions at the farm. Appropriate emergency actions are not established by the government to minimize the risk of pollution hazards.	Following steps should be taken for maintaining human welfare and safety: • Investigate alternative energy sources to fossil fuels (wind, solar, bio-fuels) and adopt them where feasible • Recycle organic wastes and inorganic materials, where possible • Minimize non-usable wastes and dispose of them responsibly • Store fertilizers and agrochemicals securely. • Used empty containers of pesticids, fertilizer, expired pesticide & fertilizer should be disposed responsibly.	• Human welfare and safety measures provide the better life of the farmers, workers and employees which can be helpful to maintain for the optimum balance between the economic, environmental and to achieve the social goals.

9. Human Welfare and Safety		
• Farmers have poor knowledge about the human welfare and safety measures. • Due to lack of knowledge optimum balance between economic environment and social goals not maintained. • They have inadequate house hold income and low levels of food security.		By adopting following two relevant points farmers can achieve the higher economy level, good environment conditions and achieve the desirable social goals.

10 Land Management in protected Forest Areas		
Existing practices followed by the farmers: • Protected Forest conservation is not maintained upto the mark i.e. poor management of diversified cropping system not followed. • Field margins not maintained clean by the farmers. Therefore, noxious weeds / unwanted plants found on the bound-		• Conservation of protected Forest Area habitats provided opportunity for the development of tourism and it can produce better revenue to the govt. • Efficient management for water courses and wet land to encourage the wild life and to prevent the pollution. • It provides better opportunity for employment.

ary of field. • Poor management of water courses and wet lands which affects the wild life and create the pollution problems and unavailability of waters in the water courses. • Good plants and animal species cannot be maintained satisfactorily.		
11. Hygiene		
• Farmers have very poor knowledge about maintenance of hygiene during the handling of farm produce. • Farmers and farm workers do not clean their hands properly while carrying out various operations at the farm. • They do not use clean clothes, aprons and hand gloves during doing various farm operations.		• Hygienic food provide better market opportunity to the farmers. • Hygienic food maintain the good health of the consumers.

And henceforth there will be a possibility of contamination of farm produce.		
12. Hand Washing		
• Farmers have inadequate knowledge about how to wash their hands properly or some..... that is not ..... • Farmers have inadequate facility to clean or wash their hands properly at the farm. • They are not utilizedsoaps, paper towels, wash basins and warm water to get cleaned their hands due to lack of facilities and knowledge.		• By adopting good techniques of hand washing, farmers can harvest good quality of farm produce. He can get good market rates for his farm products. • Consumer want better quality of hygienic and pure food. Good willing to pay higher price. Hence, if clean food are supplied better price can be fetched.
13. Water Source		
• Farmers have little knowledge about scientific management of water sources. • Due to lack of proper conveyance system, irrigation water can be contaminated by the		• By maintaining better management system for the water sources like water harvesting and water recharging practices and better maintenance of water sources farmers can get the

surface water and get polluted byfertilizers, pesticides and manure.		sufficient quantity of water for his farm and get better harvest which can increase the income of the farmers.
14. Manure		
Farmers follow indigenous practices for use and application of manures - are as under: • They are not preparing FYM, composting scientifically. That's why problems of pests, and soil borne diseases are prevalent. • They are not well practicing green manuring through sunnhemp, ekkad, cluster bean, etc on their fields and they are not properly mixing up the soil properly and timelyto maintain moisture in the soil. • Farmers are not applying manures as per recommended rates per hectare of land,		• By utilizing good quality of FYM, green manure crops, crop residues, cakes etc in sufficient quantity in the soil that can improve the physical, chemical and biological properties of the soils responsible for higher yield of the crops. • The balance use of manures and fertilizers minimize the cost of cultivation. • It can improve the water holding capacity of the soil and increase the microbial activity in the soil. • The microbes can fix the atmospheric nitrogen in the soil and maintain the fertility of the soil which can also improve the good aeration in the soil.

hence inadequate use of manure. Therefore, favourable soil physical, chemical and biological properties cannot be maintained.		

IRRIGATION

Crop production can be carried out under rain-fed conditions, irrigation or both under rain-fed and supplemental irrigation.

Irrigation: Irrigation is the intentional application of water by humans to the soil for crop production.

Advantages:

- Usually better crop yield,
- Crops not vulnerable to drought

Disadvantage:

- Cost of system components (pipes, sprinklers, pump, etc.)
- Installation cost
- Maintenance and repair cost

Irrigation could also be used to:

- Apply fertilizer (fertigation)
- Flush excessive salts in the soil (mitigate salinity)
- Cool the crop during extreme high temperatures
- Prevent crop frost damage in freezing temperatures

Rain-fed : Natural application of water to the soil through rainfall.

Advantages:

- Less expensive,
- No maintenance of system

Disadvantage:

- Poor or crop loss during low rainfall or drought.
- We have no control on the amount and distribution of rainfall.

By Dr Nathan Bailey-FAMU

Primary Considerations in Developing an Irrigation System:

1. Soil, Climate, and Topography
2. Water source (groundwater/well, river or lake?)
3. Crop(s) to be grown
4. Energy, labour, and capital
5. Commodity/product market, national policy and priority
6. Environmental aspect (salinity, water conservation, erosion)
7. Socio-cultural aspect (interrupt people's way of life?)

Primary Concepts Soil Water

Infiltration: Entry of water into soil

Percolation: Downward movement of water within the soil

Soil acts as a sponge to take up and retain water

Pore space: (in soil) the conduit that allows water to infiltrate and percolate.

Soil has big and small pores

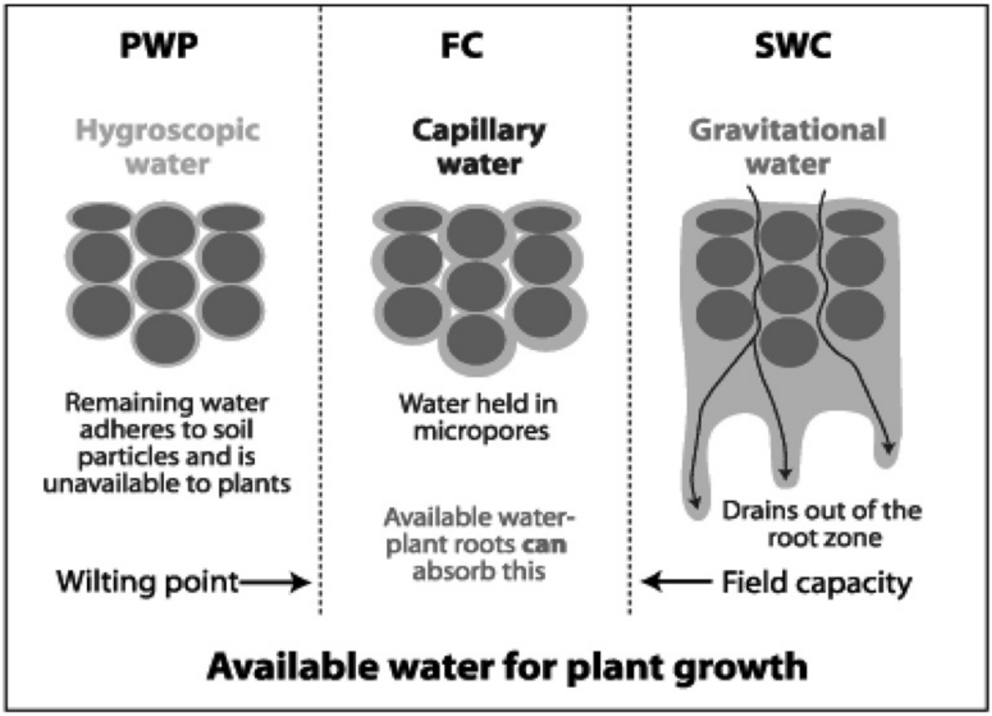
Infiltration is higher in dry soil with big pores

Soil at Saturation – All soil pores are filled with water

Primary Concepts of Soil Water for Crops

Types of water in soil

- **"HYGROSCOPIC WATER"** (Adhesion Water, Remove by oven drying, not considered available to plants) – When soil appears completely dry, but only air dry –
- **"CAPILLARY WATER"** (cohesion water, remove by air drying, Most is available to plants [some unavailable to plants (especially in clay or soils with high organic matter content]). The "small pores" (in soil) can hold water against pull of gravity through capillarity.
- **"GRAVITATIONAL WATER"** (drains through soil under influence of gravity, through large pores and considered not available to plants).
- **"FIELD CAPACITY"** - Amount of water in soil after free drainage has removed gravitational water (2 – 3 days). At Field Capacity: Soil is holding maximum amount of water available to plants. Plants can extract water easily from soils that are near field capacity.



Primary Concepts

Crop Wilting Point

- **Wilting point:** Amount of water in soil when plants begin to wilt (is not the same for all plants, for example Sunflower can extract more water from soil than maize)
    - **Permanent wilting point (PWP):** If moisture decreases to this point or any lower point a plant wilts and can no longer recover its turgidity when placed in a saturated soil for 12 hours.
    - **Temporary wilting point** in plant is **wilting** that occurs in hot weather when the rate of transpiration exceeds the rate at which a plant can absorb moisture from the soil. The plant recovers when the temperature falls and transpiration is lower than absorption.
    - Sandy Soil wilting point: The volumetric soil moisture content will have dropped to around 5 to 10%.

- Loam Soil wilting point: The volumetric soil moisture content will have dropped to around 10 to 15%.
- Clay Soil wilting point: The volumetric soil moisture content will have dropped to around 15 to 20% in clay soils.

Irrigation / Irrigation System Types Overview

Four major categories of irrigation:

1. Surface
    i) Drip/trickle (Very efficient, growing popularity in India).
    ii) Sprinkler
    iii) Flood (basin)
    iv) Furrow/channel
2. Subsurface (Not prevalent in India).

Three types of surface irrigation

Flood irrigation: where the entire surface of the soil is covered by ponded water.

Border irrigation: water is applied to rectangular strips of the field. Borders typically have a slope in the direction of irrigation, but not laterally.

Furrow Irrigation: irrigation normally used with clean-tilled crops where water is applied in furrows or rows.

1. Flood (Basin) Irrigation

- Historically, probably the first type of irrigation.
- Release water until the entire field is covered.
- Delivered to the field by ditch, pipe, or other means
- Water simply flows over the ground through the crop.

This is the most inefficient irrigation system compared with other types of irrigation.

Figure 1. Flood or basin irrigation

Efficiency of flood irrigation can be improved by:

- Levelling fields – because water is transported using gravity it won't reach high spots in the field.
- Surge flooding – rather than releasing water all at once, it is released in intervals allowing each release to infiltrate the soil before releasing additional water.
- Recycling runoff – water that runs off the end and sides of the irrigated are is captured in low-lying areas and pumped to the top of the field where it can be reused.

2. Border Irrigation

- Borders can be up to 60 m or more in length and 3-30 m wide depending on a variety of factors.

Suitable crops: Close growing crops such as pasture or alfalfa are preferred.

Suitable soils: Deep homogenous loam or clay soils with medium infiltration rates are preferred. Heavy, clay soils can be difficult to irrigate with border irrigation because of the time needed to infiltrate sufficient water into the soil. Basin irrigation is preferable in such circumstances.

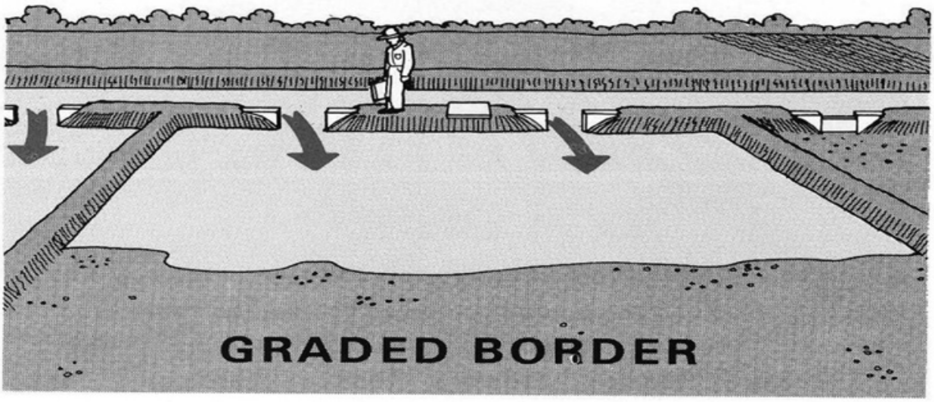


Figure 2. Graded border irrigation

Table 1. Factors to be considered in Border irrigation (slope and soil type, maximum lengths and widths).

Soil type	Border Slope (%)	Unit flow per metre width (l/sec)	Border Width (m)	Border Length (m)
SAND	0.2-0.4	10-15	12-30	60-90
Infiltration rate greater than 25 m/h	0.4-0.6	8-10	9-12	60-90
	0.6-1.0	5-8	6-9	75
LOAM	0.2-0.4	5-7	12-30	90-250
Infiltration rate of 10 to 25mm/h	0.4-0.6	4-6	6-12	90-180
	0.6-1.0	2-4	6	90
CLAY	0.2-0.4	3-4	12-30	180-300
Infiltration rate less than 10mm/h	0.4-0.6	2-3	6-12	90-180
	0.6-1.0	1-2	6	90

Note: *The flow is given per metre width of the border. Thus, the total flow into a border is equal to the unit flow multiplied by border width (in meters).*
Table above provides a guideline to determine maximum border dimensions. It must, however, be stressed that this table is for general guidance only as the values are based on field experience and not on any scientific relationships.

3. Furrow Irrigation

Furrow irrigation is a type of surface irrigation in which trenches or "furrows" are dug between crop rows in a field. Farmers flow water down the furrows (often using only gravity) and it seeps vertically and horizontally to refill the soil reservoir.

Figure 3. Furrow irrigation system

- Furrows are small, parallel channels, made to carry water in order to irrigate the crop. The crop is usually grown on the ridges between the furrows.
- Furrow irrigation is suitable for many crops, especially row crops.
- Crops that would be damaged if water covered their stem or crown should be irrigated by furrows.

4. Alternate Furrow Irrigation

Alternate furrow irrigation (AFI)is based on partial root drying technique for vegetables.

1. Irrigating only one side of the plant, i.e., half of the root system, at each irrigation while the other side receives water on the next irrigation.
2. Relying on soil moisture regulation of root to shoot signalling and control of stomata conductance and water transpiration and increase water use efficiency.
3. Managing so that yields are not significantly affected by a reduction instomatal conductance, which can increase water use efficiency.

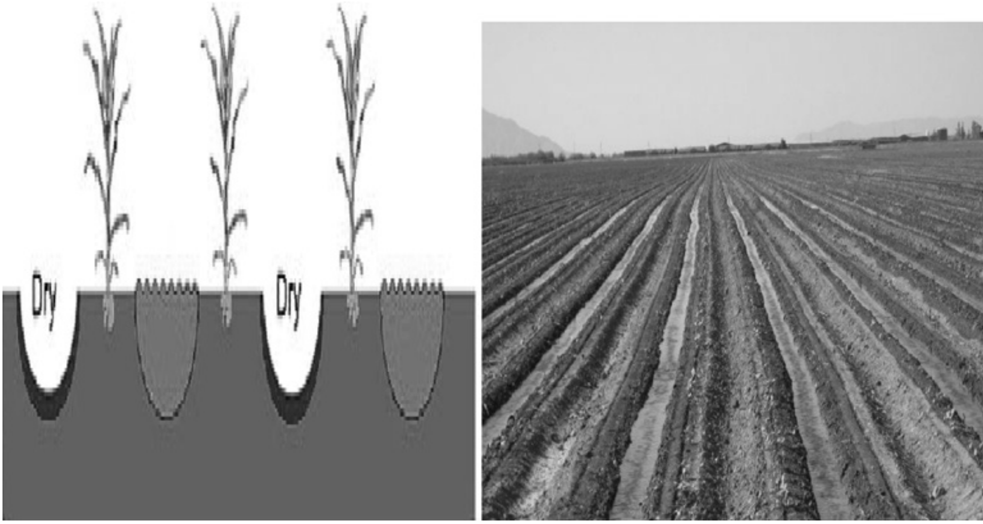


Figure 4. Alternate furrow irrigation

About 50% of the area planted to processing tomatoes in California (United States) is under alternate furrow irrigation.

Drip Irrigation

Drip: A planned irrigation system in which water is applied directly to the root zone of plants by means of applicators (orifices, emitters, porous tubing, perforated pipe, etc.) operated under low pressure with the applicators being placed either on or below the surface of the ground. In this type of irrigation, evaporation and runoff are minimized.

- Modern drip irrigation which was invented in Israel in 1959, has arguably become the world's most valued innovation in agriculture since the invention of the impact sprinkler.
- Drip irrigation may also use devices called micro-spray heads, which spray water in a small area, instead of dripping emitters (micro-spray generally used on tree and vine crops with wider root zones).
- Subsurface drip irrigation (SDI) uses permanently or temporarily buried dripperline or drip tape located at or below the plant roots. It is becoming popular for row crop irrigation, especially in areas where water supplies are limited or recycled water is used for irrigation.

Figure 5. Emitters and spray jetsused in micro irrigation

Characteristics and components of a Drip Irrigation:

- Emitters and Spray Jets
- Each Emitter output as low as1/2 gallon per hour (2 liters per hour)
- System is easily adapted for “fertigation” (irrigation and fertilizer application)
- Valves allow you to irrigate smaller field section at a time
- Timers and Automatic Solenoid Valves Make System Easy to Completely Automate
- Requires a greater level of expertise in management and maintenance.
- Could be expensive relative to other irrigation types

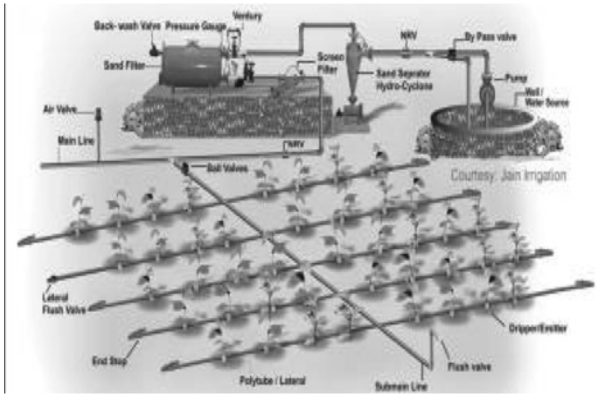


Figure 10. A schematic design of a commercial drip irrigationsystem

Figure 11. Drip irrigation under plastic mulch

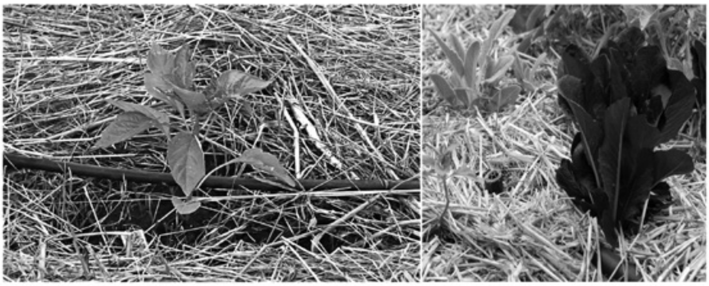


Figure 12. Drip irrigation under straw mulch

Component of Micro Irrigation
Plastic/PE Tubing

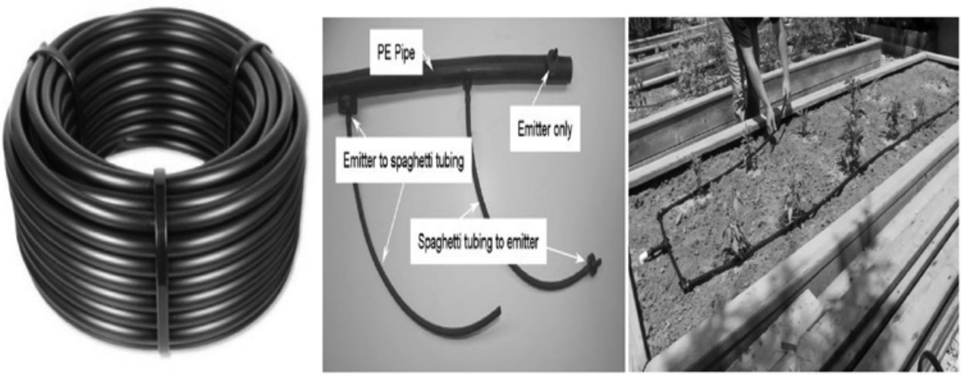


Figure 6. Plastic/PE tubingused in drip irrigation.

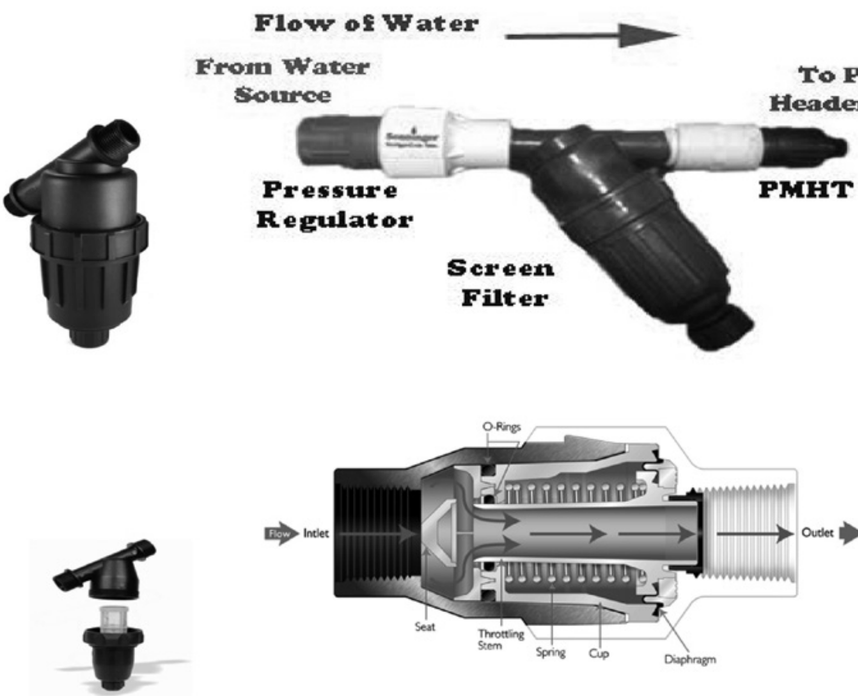


Figure 7. Filters and pressure regulatorsused in drip irrigation.

Drip Irrigation: Flushing

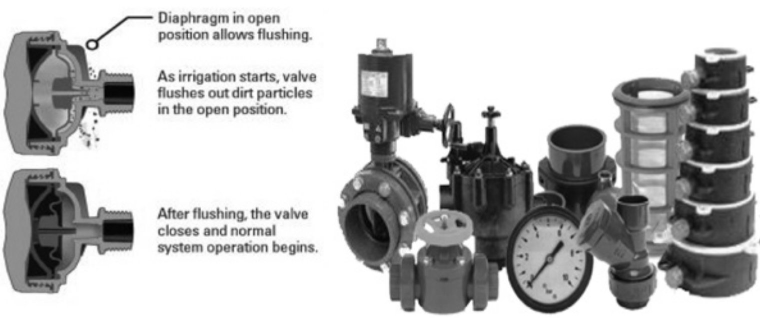


Figure 8. Flushing gearused in drip irrigation

Drip Irrigation: Pumps

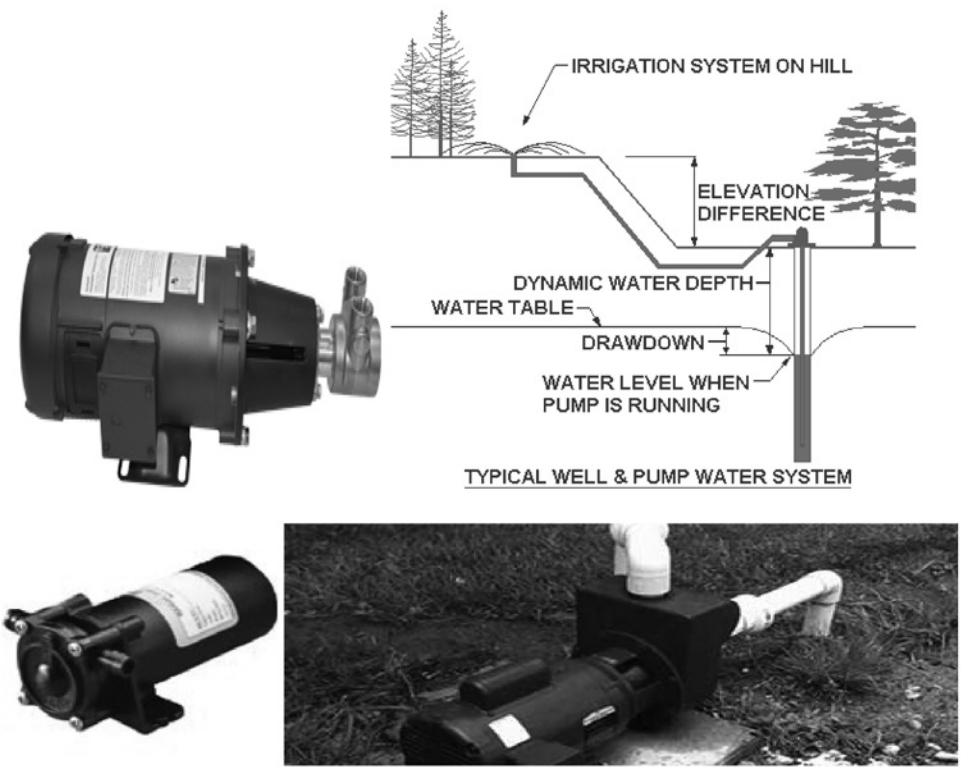


Figure 9. Pumpsused in drip irrigation

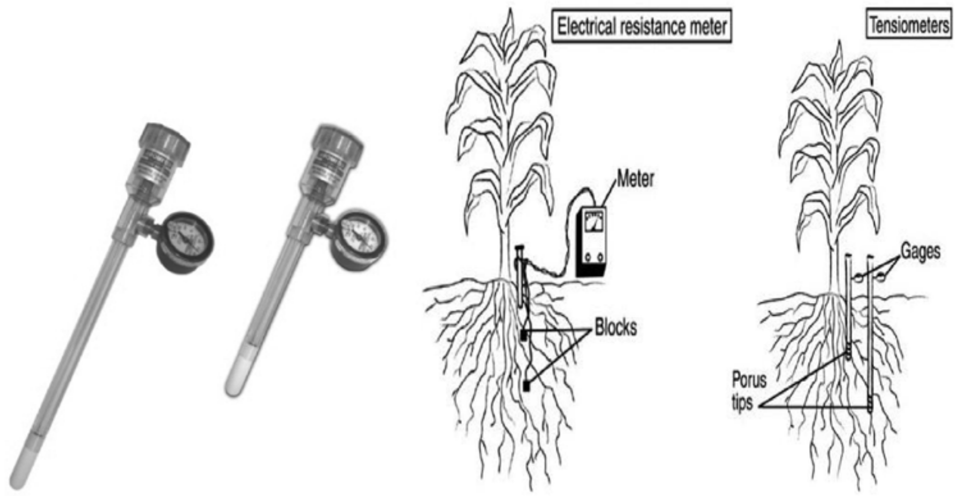


Figure 13. Scheduling irrigation based on soil moisture sensors

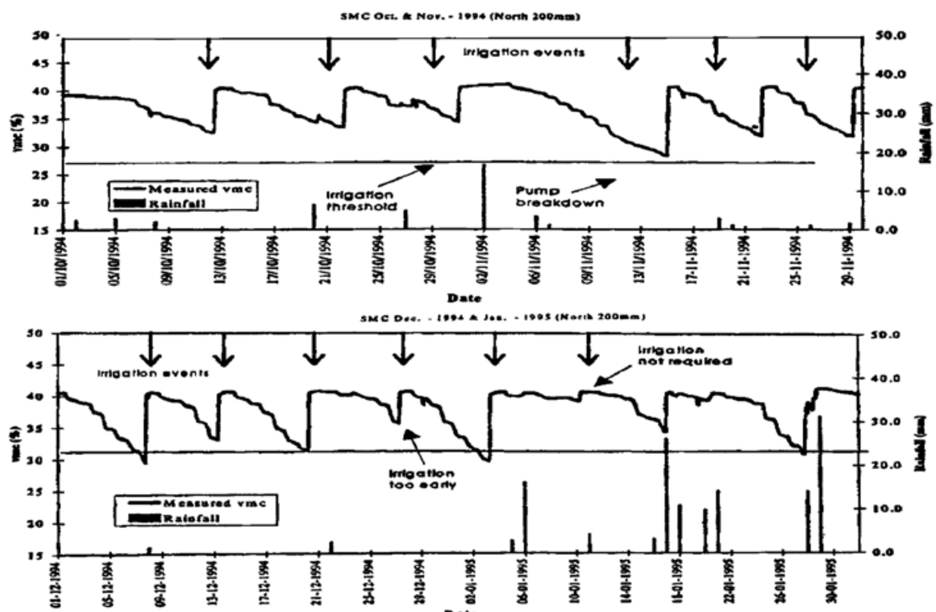


Figure 14. Irrigate there is a need based on soil moisture data

Salinity and Irrigation in India

- Approximately 30-85% of the ground water surveyed in different Indian States is rated either saline or alkaline.
- Due to continental monsoonal climate, the basic principles of saline water management need some adaptation, e.g. providing for a leaching requirement is not appropriate when the growing season for post-monsoon winter crops starts with a surface-leached soil profile, because it would increase the salt load.

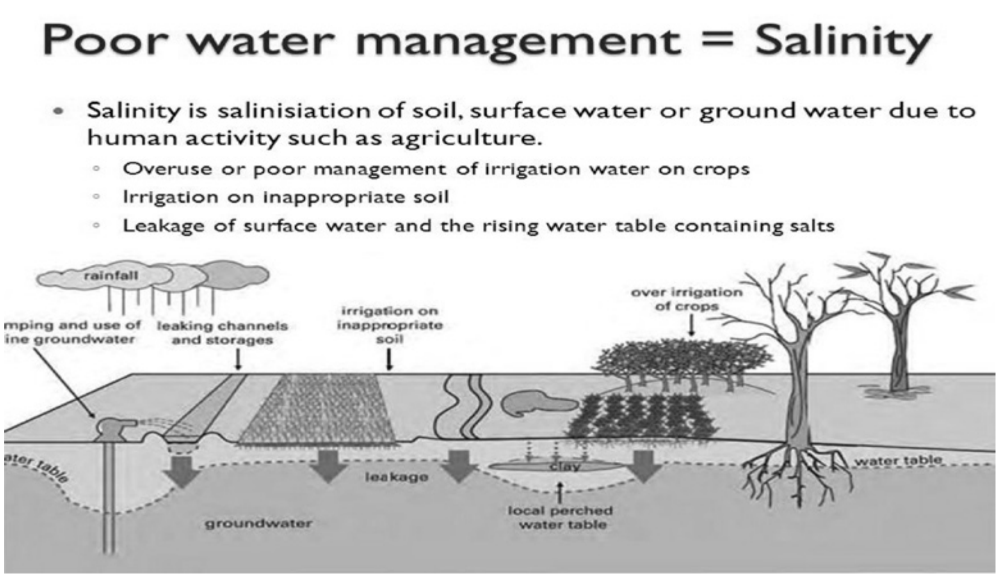
High salinity during the initial stages of growth are particularly harmful. Furthermore, if benefits are to be gained from frequent saline irrigation, the amount of water applied per irrigation needs to be reduced.

A clear solution:

1. Capture as much rainfall possible to replace or supplement saline irrigation water.
    1. Rain harvesting.
    2. Impoundment of freshwater
    3. Maximize storage and minimize system loss (i.e. seepage, evaporation)
2. Utilize lowest saline water during periods of greater crop sensitivity

Have a clear understanding of irrigation efficiency – utilize when feasible a more efficient system.

Salinity Issues Overview



Designing an irrigation system forsaline conditions

For optimal results it is necessary to know:

- the salinity of the irrigation water,
- the salinity of the soil,
- the salt tolerance of the crop,
- the climatic conditions (precipitation) and
- management of precipitation water.

Soil Texture and Crop Tolerance Information

Table 8
Guidelines for using saline irrigation waters in India

Soil texture (% clay)	Crop tolerance	ECiw (dS m^{-1}) limit for rainfall region		
		< 350	350–550	> 550 mm
Fine (> 30)	Sensitive	1.0	1.0	1.5
	Semi-tolerant	1.5	2.0	3.0
	Tolerant	2.0	3.0	4.5
Moderately fine (20-30)	Sensitive	1.5	2.0	2.5
	Semi-tolerant	2.0	3.0	4.5
	Tolerant	4.0	6.0	8.0
Moderately coarse (10–20)	Sensitive	2.0	2.5	3.0
	Semi-tolerant	4.0	6.0	8.0
	Tolerant	6.0	8.0	10.0
Coarse (< 10)	Sensitive	–	3.0	3.0
	Semi-tolerant	6.0	7.5	9.0
	Tolerant	8.0	10.0	12.5

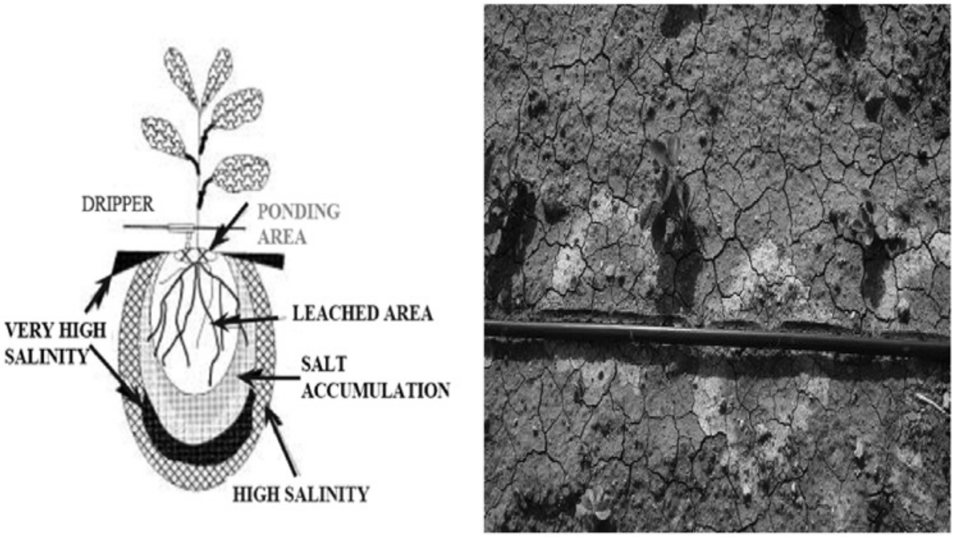
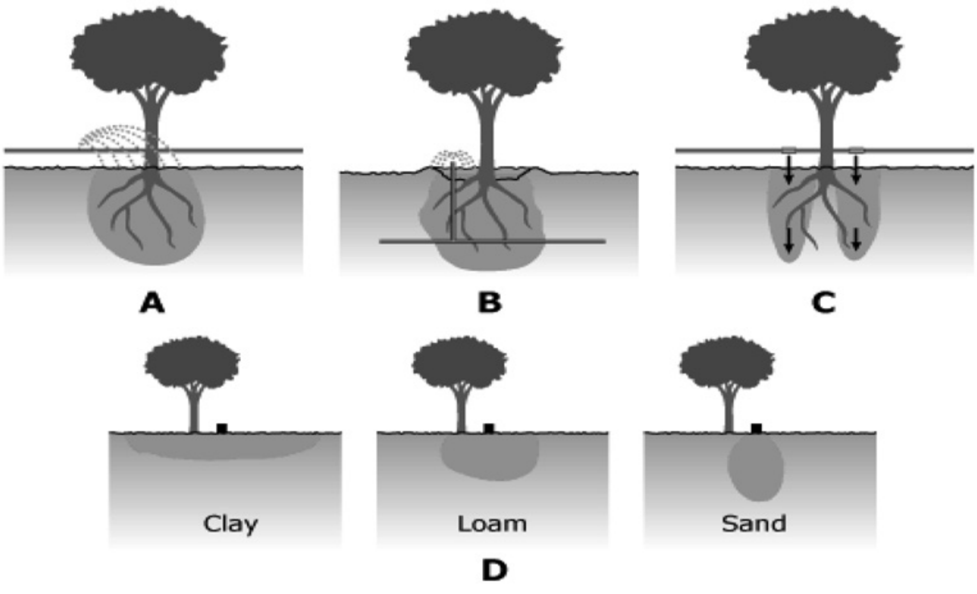


Figure 15. Salt accumulation in drip irrigation.



Measurements of Irrigation Efficiency

Table 2. Different types of irrigation methods are the corresponding efficiencies.

Irrigation method	Field application efficiency
Surface irrigation (border, furrow, basin)	60%
Sprinkler irrigation	75%
Drip irrigation	90%

- **Irrigation efficiency** (IE) is the ratio of the amount of water consumed by the crop to the amount of water supplied through irrigation (surface, sprinkler or drip irrigation).
- **Is flood irrigation efficient?**

  Flood irrigation is not the most **efficient irrigation** method, but it is cheap and low-tech. On the one hand, less water is lost to evaporation than in spray irrigation, but on the other hand, more water can be lost from runoff at the edges of the fields.
- **What is water conveyance efficiency?.... water conveyance efficiency:** Ratio of the volume of irrigation water delivered by a distribution system to the water introduced into the system.
- **What is water application efficiency?**

  Water application efficiency is a measurement of how effective the irrigation system is in storing water in the crop root zone. It is expressed as the percentage of the total volume of water delivered to the field that is stored in the root zone to meet crop evapotranspiration (ET) needs.

Water Application Efficiency (E_a)

Water application efficiency (E_a) provides a general indication of how well an irrigation system performs its primary task of delivering water from the conveyance system to the crop. The objective is to apply the water and store it in the crop root zone to meet the crop water requirement. Ea is a measure of the fraction of the total volume of water delivered to the farm or field to that which is stored in the root zone to meet the crop evapo-transpiration (ET) needs. E_a is expressed as:

$E_a = (V_s / V_f) \times 100$ (1)

= water application efficiency (%)

= volume of irrigation water stored in the root zone (acre-inch)

= volume of irrigation water delivered to the farm or field (acre-inch)

Water Conveyance Efficiency (E_c)

Irrigation water is normally conveyed from a water source to the farm or field through natural drainage ways, constructed earthen or lined canals, or pipelines. Many conveyance systems have transmission losses, meaning that water delivered to the farm or field is usually less than the water diverted from the source. Water losses in the conveyance system include canal seepage, canal spills (operational or accidental), evaporation losses from canals, and leaks in pipelines.

$E_c = (V_f / V_t) \times 100$ (2)

= water conveyance efficiency (%)

= volume of irrigation water that reaches the farm or field (acre-inch)

= volume of irrigation water diverted from the water source (acre-inch)

Overall Irrigation Efficiency

Overall Irrigation Efficiency (E_0)

The overall irrigation efficiency (E_0) represents the efficiency of the entire physical system and operating decisions ¬in delivering irrigation water from a water supply source to the target crop. It is calculated by multiplying the efficiencies of water conveyance and water application:

$$Eo = (Ec \times Ea) \times 100$$

Eo = overall irrigation efficiency (%)

Ec = water conveyance efficiency (decimal)

Ea = water application efficiency (decimal)

Potential Application Efficiencies Comparison of Irrigation Methods

Properly designed and well-managed Systems.

Irrigation System	**“Potential” Application**
Sprinkler Irrigation Systems	Efficiency (%)
LEPA	80 - 90
Linear move	75 - 85
Center pivot	75 - 85
Traveling gun	65 - 75
Side roll	65 - 85
Hand move	65 - 85
Solid set	70 - 85
Surface Irrigation Systems	
Furrow (conventional)	45 - 65
Furrow (surge)	55 - 75
Furrow (with tailwater reuse)	60 - 80
Basin (with or without furrow)	60 - 75
Basin (paddy)	40 - 60
Precision level basin	65 - 80
Microirrigation Systems	
Bubbler (low head)	80 - 90
Microspray	85 - 90
Micro-point source	85 - 90
Micro-line source	85 - 90
Subsurface drip	> 95
Surface drip	85 - 95

Uniformity of Water Application

All irrigation systems apply water non-uniformly to a varying degree. The irrigation system performance efficiency terms described previously do not directly account for the uniformity or non-uniformity of irrigation application.

For a sprinkler irrigation system, non-uniformity can be due to numerous factors: (1) improper selection of delivery pipe diameters (sub-main, manifolds, and lateral), (2) too high or too low operating pressure, (3) improper selection of sprinkler heads and nozzles, (4) inadequate sprinkler overlap, (5) wind effects on water distribution, (6) wear and tear on system components with time, such as pump impellers, pressure regulators, or nozzle size, and (7) nozzle clogging.

For surface irrigation, non-uniformity can be caused by: (i) differences in opportunity time for infiltration caused by advance and recession, (ii) spatial variability of soil-infiltration properties, and (iii) non-uniform grades.

For micro-irrigation, non-uniformity can be due to: (i) variations in pressure caused by pipe friction and topography, (ii) variations in hydraulic properties of emitters or emission points (from clogging or other reasons), (iii) variations in soil wetting from emission points, and (iv) variations in application timing,

Low-Quarter Distribution Uniformity (DU) for Surface Irrigation Systems

The distribution uniformity is more commonly used to characterize the irrigation water distribution over the field in surface irrigation systems, but it also can be applied to micro and sprinkler irrigation systems. The low-quarter distribution uniformity (DU) is defined as the average depth infiltrated in the low one-quarter of the field divided by the average depth infiltrated over the entire field. It is expressed as:

$D_U = (D_{lq} / D_{av}) \times 100$

= distribution uniformity (%)

= average depth of water infiltrated in the low one-quarter of the field (inch)

= average depth of water infiltrated over the field (inch)

Typically, DU is based on the post-irrigation measurement of water depth that infiltrates the soil because it can be more easily measured and better represents the water available to the crop. However, using post-irrigation ¬measurements of infiltrated water to evaluate DU ignores any water intercepted by the crop and evaporated, and any soil water evaporation that occurs before the measurement. Any water that percolates below the root zone or the sampling depth also will be ignored. A low DU (<60%) indicates that the irrigation water is unevenly distributed, while a high DU (<80%) indicates that the application is relatively uniform over the entire field.

Summary – Irrigation Options

- There are multiple approaches and options for all Irrigation Methodologies available for localities in India combating salinity in source water and soils.
- The approaches range in level of complexity and costs.
- Knowledge about the design parameters is paramount.
- There should be a willingness to experiment with methods, especially with the goal towards finding ways to reduce costs.

Efficiency Summary

- Irrigation efficiency is described by several terms used to measure how efficiently irrigation water is applied to the field and/or used by the crop.
- High irrigation efficiency translates into lower operating costs, improved production per unit of water delivered, and improved environmental benefit and management.
- Incorrect use of efficiency terms can lead to misrepresentation of how well an irrigation system is performing. Therefore, it is important for both producers and irrigation management professionals to select the appropriate efficiency and uniformity parameters when evaluating irrigation systems.
- The efficiency and uniformity indices described here can be a measure useful in to achieving more efficient irrigation management that will lead to conserving water and protecting environmental quality in irrigated agriculture.
- By following efficient use of water a farmer can reduce his cost of production.

Subsurface Irrigation

➢ Sub-irrigation: Applying irrigation water below the ground surface either by raising the water table within or near the root zone or by using a buried perforated or porous pipe system that discharges directly into the root zone.

➢ Water is distributed across land by raising the water table, through a system of pumping stations, canals, gates, and ditches. This type of irrigation is most effective in areas with high water tables.

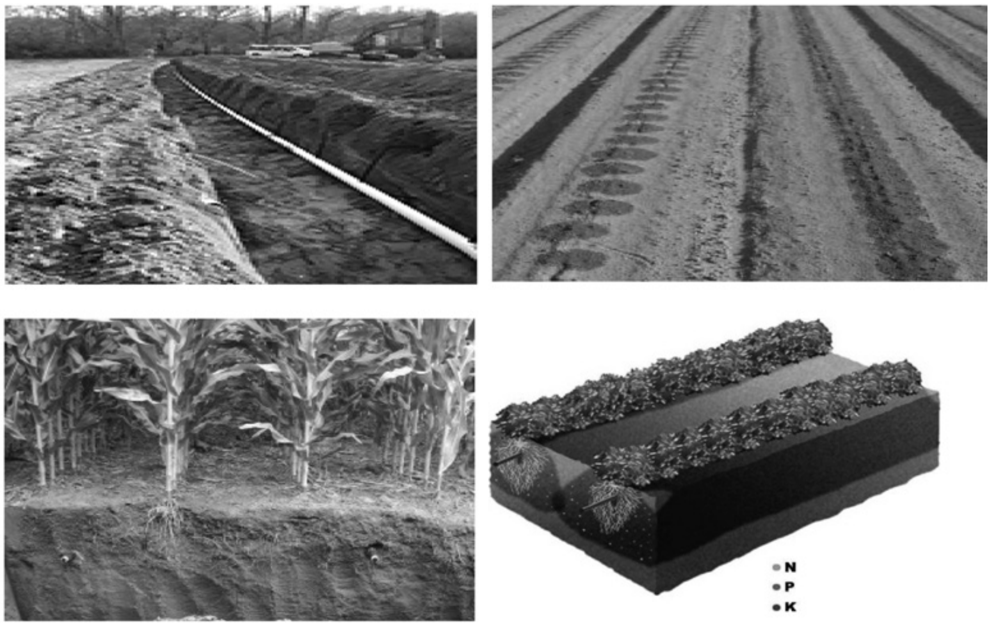


Figure 16. Examples of subsurface irrigation drip lines

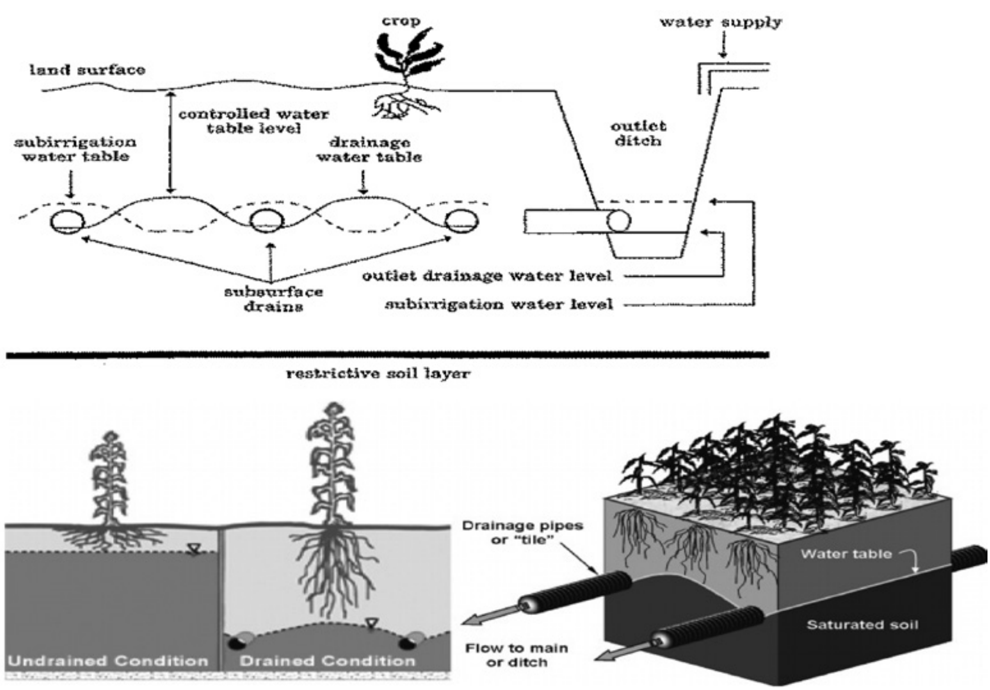


Figure 17. Management of water table in subsurface irrigation

Types of Irrigation:

Figure 18. Sprinkler solid set andlateral move irrigation system

Figure 19. Center pivot irrigation system

POST-HARVEST MANAGEMENT

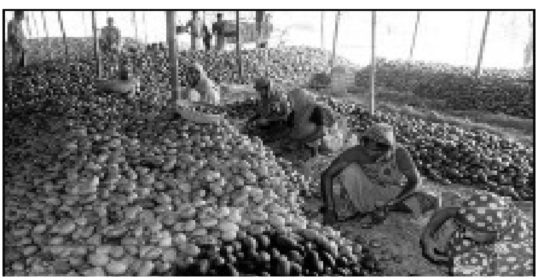
Introduction

- India is the world's largest producer of fruits, accounting for about 8% of total world fruit production.
- However, between 20 and 30% of India's fruit production goes to waste due to poor post-harvest management.
- Losses are estimated at approximately Rs 40,811 crore ($6 billion), annually

The need for Post-Harvest Intervention

1. Improve product shelf life
2. Improve product appearance
3. Improve product value
4. Ensures that the product complies with established quality standards
5. Reduce losses and
6. Improve revenue and food security

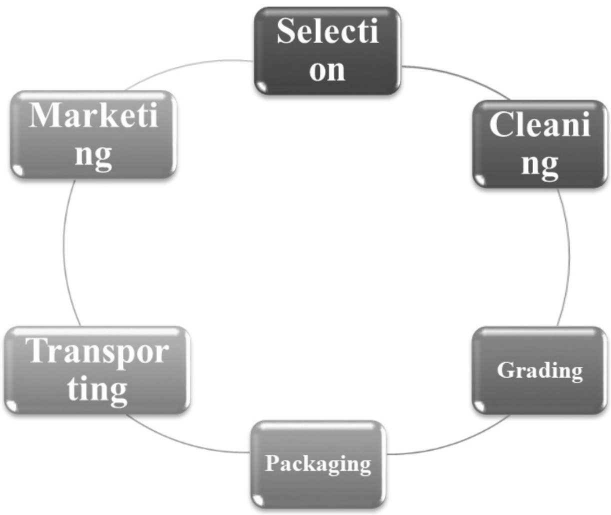
- Once harvested, the overall quality of fresh fruits can hardly be improved but it can be maintained with good post-harvest practices
- Focus should be on methods/ activities that :
    - are realistic



by Dr Gilbert –FAMU

- are efficient (prevent waste)
- are cost effective
- can create employment

Post-harvest activities include but are not limited to:



Post-harvest management begins with good pre-harvest practices

1. Frequency of irrigation (watering)
2. Fertilizing (organic/inorganic)
3. Pest and disease control
4. Cultivation practices
5. Harvesting practices (time and methods)
    - These affect the quality of the final product

Pre-harvest activities can influence overall fruit quality

Some Examples:

- Spraying gibberellic acid (25 ppm) at full bloom can increase yield and fruit retention.
- Gibberellic acid (10 ppm) at color break stage, can delay color development and maintain firmness.
- Pruning can result in larger fruits.
- Harvesting practices can damage fruits or accelerate decay.

POST-HARVEST QUALITY CONTROL MEASURES

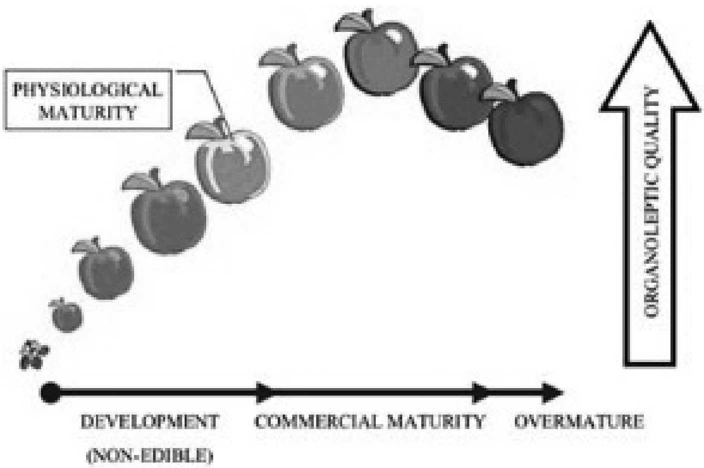



- We must consider the natural processes that occur in fruits and learn how to control/manipulate them
    1. Respiration
    2. Transpiration
    3. Ethylene production
    4. Maturity
- We must also consider the external factors that can cause fruit deterioration



Respiration

- A process in all living organisms involving the intake of oxygen and the release of carbon dioxide to produce energy
- Respiration continues after the fruit is harvested and is important to keep them fresh.



The not so good thing about respiration

- Since the process of respiration uses food reserves stored in the fruit, it results in fruit deterioration over time.
- This is exhibited in loss of nutritional value, changes in texture, color, flavor, and loss of weight.
- These negative effects lower the market value of fruits.

Important things to know

1. Temperature is perhaps the most significant factor in post-harvest management of fruits.
2. The rate of fruit deterioration doubles for each 10 °C rise in temperature.
3. Temperature regulation is the most effective way of extending shelf life of fruits and vegetables.
4. Temperature above/below the optimum can cause heat or frost damage.

Optimum Temperature for Selected Crops

Crop Type	Optimum temperature (0 0C)	Storage life (weeks)
Mango	13	2 - 4*
Date palm	- 18 to 0	24 - 52*
Pomegranate	5	8 -12*

Post-harvest Treatment: Pre-cooling

- The rapid cooling of fresh produce from field temperature (pulp temperature at the time of harvesting) to its best storage temperature.
- The main objective is to remove field temperature (field heat).
- Removing field heat reduces the rate of the natural processes that occur in fruits hence increases their shelf life.

Comparison of Pre-Cooling Methods

Variable	Cooling Method				
	Ice	Hydro	Vacuum	Forced air	Room temp.
Cooling times (hours)	0.1 – 0.3	0.1 – 1.0	0.3 – 2.0	1.0 – 10.0	20 - 100
Water contact	yes	yes	no	no	no
Moisture loss (%)	0 – 0.5	0 – 0.5	2.0 – 4.0	0.1 – 2.0	
Cost	high	low	medium	low	low
Energy efficiency	low	high	high	low	low

Pre-cooling Methods

Forced Air (recommended)

- Cool air with high speed moves over the fruits to remove the field heat. Both packed and unpacked fruits can be pre-cooled

Pre-cooling Innovations

A. Farmer buys an abandoned trailer and customizes it (wooden pallets, shelves, etc.)

B. Farmer buys a low cost refrigeration unit and installs it.

Note: Electricity was available.

Post-harvest Treatment: Managing Ethylene Gas

- Fruits produce ethylene gas which affects the ripening process
- The amount of ethylene depends on whether fruits are classified as climacteric or non-climacteric

The Amount of Ethylene gas Depends on Type of Fruit

1. **Climacteric:**
   - Give off large amounts of ethylene gas
   - the fruit is fully developed but may not be ready for immediate consumption (mango, date palm, papaya, pineapple guava and banana).
2. **Non-Climacteric:**
   - Give off little or no ethylene gas
   - Ready to eat at maturity.
   - Do not ripen after harvest (pomegranate , grape, citrus)

Nine things to know about ethylene production

1. Ethylene gas is an important artificial ripening agent for climacteric fruits.
2. However, one over-ripe fruit can induce spoilage in an entire crate of fruits.
3. When the concentration of ethylene reaches 0.1-1.0 ppm in climacteric fruits, the ripening process is considered irreversible.
4. Reducing ethylene is key to longer shelf life.
5. Avoid keeping sources of ethylene gas close to your storage room.
6. Refrigeration reduces the rate of ethylene production.
7. Carbon dioxide (Co2) also reduces the rate of ethylene production.
8. Potassium permanganate has been scientifically proven to absorb ethylene.
9. Stress or damage to fruits speeds up ethylene production.

Post-harvest Treatment: Maturity and Ripening (Mango)

- Red/yellow skin is not a good indicator of maturity, ripeness, or fruit quality
- Train workers to know the optimum maturity stage
- Maturity can be judged by factors such as internal color, peel color, firmness, degrees Brix and fruit shape.

Maturity and Ripening: Mango

- Internal flesh color, which develops near the seed and progress outward is generally the best indicator of maturity and ripeness.

Harvesting and Storage: Mango

- Harvest mangoes with a long stem (about 5 cm or longer) to avoid latex drip.
- Trim stems to the abscission zone (approximately 1 cm) and immediately place the fruit with the stem end down to allow latex to drip.
- Store mangoes with the tip down for efficient latex removal (ranges between 20 minutes to 4 hours).

Additional things to know about maturity and harvesting

1. Maturity varies from species to species
2. Fruits to be shipped should be picked at a mature but unripe stage
3. Control/manipulate ethylene production
4. Best temperature for ripening mango is 20^{o} C – 22^{o} C
5. Again, it is good to know fruit types (climacteric/non-climacteric)

Controlling External Factors

- Biological: Pests and diseases
- Chemical: Toxic sprays, pesticides, unpleasant flavors left by insects etc.
- Mechanical: injury from cuts, bruises, dirt
- Physical: Sunburn, heat, freeze, dehydration, latex scalds, etc.

Packaging Storing and Transporting

- Be careful not to damage fruits.
- Avoid large piles.
- Do not pack fruits with different stages of maturity.
- Do not over-fill cartons.
- Ensure that air can circulate around the fruits in the carton.

Packaging Storing and Transporting

- Use plastic crates or crates lined with polyethylene material.
- Do not over-stack crates.
- For long distance and international transport, use refrigerated trucks.

Summary

- Pre-cooling is a compulsory post-harvest treatment in developed countries for almost all perishable commodities.
- The quality of fresh fruits and vegetables largely depends on precooling before storage and marketing.
- Expensive equipment does not always imply high efficiency.
- Post-harvest fruit quality depends on pre-harvest agricultural practices.
- Time of harvest can affect fruit quality. Harvest during the cooler periods of the day, usually before 10:00 AM
- Train workers to know the optimum stage of fruit maturity.
- Do not overload storage rooms or stack boxes tightly as it will hinder air movement through all boxes.
- Monitor temperature in the storage room by placing thermometers at different locations.
- Remove damaged or diseased produce to prevent the spread of pathogens.
- Storage rooms should be kept clean at all times.
- Store only high-quality produce, free of damage & decay and of proper maturity.
- It is not possible to give exact amount of post-harvest losses as these commodities move through several supply chain networks.
- It is true that a small farmer may not be able to afford this on his own - but Self Help Group (SHG) or farmers cooperative or micro enterprise can setup this.

PRODUCTION RECORD KEEPING AND FINANCIAL MANAGEMENT OF SMALL FARM ENTERPRISE

Introduction

- **Everyone in business must keep records – including farming (and a farmer)**
- **Keeping good records is very important for your business - farming**
- **Good records will help you do the following:**
    - Monitor progress or lack of progress
    - Identify sources of your income
    - Keep track of your expenses
    - Keep track of your property
    - Keep track of your loans (or debts)
- **There are two sets of basic records that should be kept by an owner of a small farming enterprise.**
    - Production records
    - Financial records
- **Production records:**
    - These records document everything that is produced on the farm.
    - They are mostly prepared on weekly basis which add up to monthly and annual records.
    - These records monitor the value of the farm produce and measure progress in production and enable individual farmers to access farm profits.

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by Mr Chester-FAMU

Benefits of Production Record Keeping

- Provides real data about past performances
- Good sets of records can help you make better business decisions
- Predict future trends
- Government Assistance programs when available

Records for farm use:

- These records show the dates for land preparation
- Planting of different plots, sale or utilization of produce and rotation programs.
- They also include difficulties encountered on the farm such as disease and pest outbreaks.

Others:

- Farm expenditure records: Farm inputs used
- Workers records: Salaries and other payments
- Vehicle records: Petrol, oil used and any repairs

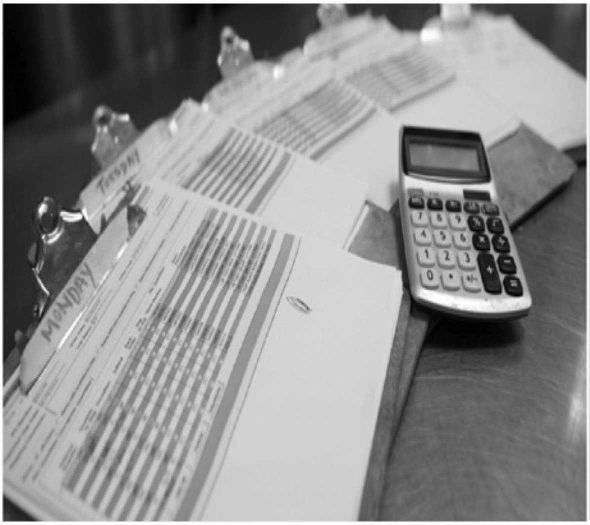
General Principles

- Accountability
- Protection
- Retention
- Disposition
- Transparency

What is Production Record Keeping?

- Track details of day to day production such as inventories, inputs consumed, and products sold.
- Track the number of animals in a herd, acres planted of a specific crop, crop yields or amount of product produced.
- Track amount of inputs used to raise your crops or animals to help track input consumption and expenses, and anticipate future input needs.

Methods of Keeping Production Records



Examples of Record Keeping

- Produce applicants, i.e. manure, pesticides, nutrient, irrigation
- Planting/Harvesting
- Employee Training
- Breeding (livestock record), birth

Types of Production Records

Chemical Application						
Field	Chemical	Date	Time	Acres	Application Rate	Notes

Fertilizer Record												
Field	Soil Test Date	Soil Test Results						Suggested Application Rate	Application Date	Acres	Application Rate	Notes
		N	P	K	Ca	Zn	Fe					


Planting/Harvesting

Seeding, Planting and Harvesting Record

Crop	Variety/ lot	Location	Seeding date or wet date (irrigation)	Trans-plant Date	Date of Harvest	Yield

Seeding, Planting and Harvesting Record

Crop	Variety/ lot	Location	Seeding date or wet date (irrigation)	Trans-plant Date	Date of Harvest	Yield
Mango						
Date Palm						
Pomeg-ranate						

Seed Starting						
Date	Crop	Seed Source	Amount Seeded	Amount Germinated	Transplant Date/Location	Note

- Use this chart if you plan to start your seeds indoors.
- Because not all seeds are started at the same time keeping seed-starting records is particularly helpful if you're experimenting with new crop varieties or if you're managing a large amount of seeds.
- Not all planted seeds will germinate, so tracking germination rates will indicate how much seed you need to purchase for future plantings.
- It's also a good idea record seed sources, but especially important if you're pursuing or maintaining organic certification, as you will need to document your search for organic seeds and planting stock.

Planting Chart

- Use this chart if you plan to direct-seed outdoors or if you're working with transplants
- Recording plot location and planting date will help you make future plot-rotation plans
- Knowing the bloom or fruit date enables you to plan for harvests in subsequent years.
- Be sure to take note of plant traits so you can determine what land-management actions to take, such as adding amendments or implementing pest control.
- As with seeds, you'll need to document sources of organic transplants.

Harvest Chart

- This chart is particularly helpful if you're growing on a larger scale.
- Do you have enough produce to take to market or are you always returning with extras?
- This is where the "Yield" field will come into play.
- If you've hired labor to help in the fields, you can maximize your expenditures by keeping track of labour hours.
- This chart can be helpful even on a small scale if you're growing produce to put up for the winter season.

Pest Management Chart

- By keeping these charts, whether for a small-scale or large-scale garden, you can identify the biggest pest threats to your produce and determine which management techniques are most effective.

Irrigation Chart

- Watering is important to raise a crop successfully, and it's possible to both under- and over-water a plot.
- The information you log about the amount of water a plot receives and the method used to irrigate could come into play at a later date.

Equipment cleaning chart

- While this might not be necessary for every garden, equipment-cleaning is regulated by organic-certification standards to ensure the organic integrity of your crops.
- The CCOF trade association recommends keeping a form like this for each piece of gardening equipment.

HERD TARGETS FOR PRODUCTION AND DISEASE									
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No. of breeding females	216	218	221						
Target:	220	220	220	220	220	220	220	220	220
Total matings (+ gilts)	46	88	131						
Cumulative targets:	47	94	141	188	235	282	329	376	423
Gilt matings	7	12	18						
Cumulative target:	7	14	21	28	35	42	49	56	63
Repeat matings	3	5	11						
Cumulative target:	4	8	12	16	20	24	28	32	36
Nos. farrowed	41	84	123						
Cumulative target:	42	84	126	168	210	252	294	336	378
Nos. born alive	476	899	1339						
Cumulative target:	474	948	1422	1896	2370	2844	331 8	3792	4266
Pre-weaning mortality	32	72	108						
Cumulative target:	40	80	120	160	200	240	280	320	360
Nos. weaned	440	863	1253						
Cumulative target:	434	868	1302	1736	2170	2604	303 8	3472	3906
Weaner mortality	5	12	19						
Cumulative target:	7	14	21	28	35	42	49	56	63
Grower / finisher mortality	3	10	16						
Cumulative target:	7	14	21	28	35	42	49	56	63
Weaners sold									
Cumulative target:	-	-	-	-	-	-	-	-	-
Finishers sold	401	816	1246						
Cumulative target:	420	840	1260	1680	2100	2520	294 0	3360	3780
Sows sold	4	9	14						
Cumulative target:	6	12	18	24	30	36	42	48	54

An Example of targets set for a 220 sow herd selling finished pigs.
(Fig.3-17)

Study name: **Study PI:**
Study ID #:

Staff Member Training Log

Study Staff Member Name:

Date Training	Description of Training	Expiration date (if applicable)

Summary

- What is Production record keeping?
- Production record keeping is useful (Why)?
- General principles of record keeping help one understand the importance:
- Accountability
- Protection
- Retention
- Disposition
- Transparency

Financial Management of Micro Enterprise

What is Microcredit Finance?

- Small loans, given mainly to low income.
- Microcredit offers access to credit to those people traditionally banks will not lend to because they lack collateral.
- Microcredit is community-driven development, dependent upon the innate creativity and potential of each individual.

It allows people to start and expand tiny businesses without depending on money-lenders who demand exorbitant interest rates.

Justification and Definition of Micro-finance

Some people excluded from certain financial services?

- Lack collateral or guarantors
- A bad credit history
- Gap in the communication / lack of confidence in the Banks
- Doubt of the bank of the repayment capacity
- Lack of access to financial infrastructure and services in remoted areas
- Lack of land records

Microcredit Best Practice: Repayment

Microfinance is not philanthropy!

- ➢ Clients need to pay for the services
- ➢ Microcredit clients need to repay the loans
- ➢ Interest rate to cover the costs

- **REPAYMENT ON TIME GUARANTEES THE SUSTAINABILITY OF THE PROGRAM**

Microcredit Best practices:

Key success factors

Methodology

- ➢ Regular follow up
- ➢ Requirement of good repayment for future access to a bigger loan
- ➢ Local loan officers familiar with local culture

Balance Sheet

- ➢ Summarizes Assets, Liabilities (Debt), Net Worth
- ➢ Net Worth = Value of Assets – Value of Liabilities
- ➢ Current (< 12 months), Intermediate (1-10 years) Long Term (>10 years), Non-farm
- ➢ "A Balance Sheet is a snapshot of the farm's financial position"

Cash Flow

- ➢ Summarizes all cash in-flows and out-flows for a period of time
- ➢ Checkbook Accounting
- ➢ In-Flows – crops & livestock sales, receipts, sale of capital assets, borrowed money
- ➢ Out-Flows – production, capital expenditures, loan payments, living expenses
- ➢ Important on farms because of seasonality
- ➢ Projected and Actual Cash Flow

Income Statement

- Summary of revenues and expenses for a specific time period
- Revenue – Receipts from sales, government payments, dividends
- Expenses – Production expenses, interest, taxes, insurance, loans
- Inventory Changes – Accrual adjustment
- Depreciation and Capital Adjustments
- Revenue – Expenses = Net Income
- Main purpose is to determine how much income was generated by the farm operation

Projected Financial Statements

- Lender, farm operation or other factors may require projected financial statements
- To do this review enterprise budgets and financial statements

Equipment Inventory

- Equipment Name
- Model
- Size
- Year Purchased
- Age
- Condition
- Ownership
- Book Value
- Market Value
- This keeps valuable information needed for your financial statements

Summary

It is important to keep accounts to understand where one is making losses. It is a must for managing even & small farmers of helps to reduce costs. The young educated farmers are also setting up their own micro-enterprice – where it is customer service – providing a tractor or sprayer pump or transporting goods for sale – He must keep proper account.

In order to become smart farmer it is not only management of water or farm – it is also management of finance that is key to increase income.

SUCCESS STORIES

- **Bumper profit – Use of plastic mulch with drip irrigation in watermelon cultivation**

Name of Farmer	**:**	**Dhirubhai Sothabhai Kagadia**
Address	:	Saipar
Taluka	:	Rajkot
Dist.	:	Rajkot
Contact Number	:	9687830314
Age	:	40 years
Education	:	7th Pass
Land holding	:	3 acre
Crops grown	:	Groundnut, Cotton, Wheat & Water melon
Livestock	:	Cow : 1 Bullock : 1 Jafrabadi buffalo : 1

SPECIAL RECOGNITION :

Farmer of Saipar village comes in contact with NCCSD-CRIDA for getting more return from his traditional cultivation. He was inspired from KVK, Targhadia and NCCSD, to cultivate watermelon using plastic mulch and drip irrigation instead of traditional method. He was provided all the information such as cultural practices, use of plastic as a mulch with drip irrigation. The farmer was convinced through the information provided by the scientists of KVK and started cultivation of watermelon and got total production of 25000 kgs from 0.5 ha land during summer 2011. The product was sold directly to local trader at good rate.

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by Dr I R Rathod with Nisha Shah -NCCSD

He earned a gross income of Rs. 2.5 lac a net profit of 2.0 lac from 0.50 ha land within three months period. This income is quite high compared to the income from other traditional crops. By observing this practice, numbers of farmers have initiated the cultivation of watermelon using plastic mulch with drip irrigation in this area. This cultivation has raised the living standard of Dhirubhai and he became the icon of watermelon cultivation in Rajkot district.

- **Use of cotton shedder and decomposting of cotton stalk**

Name of Farmer	**:**	**Govindbhai Pachabhai Undhad**
Address	:	Khorana
Taluka	:	Rajkot
Dist.	:	Rajkot
Contact Number	:	9974344119
Age	:	52 years
Education	:	8th Pass
Land holding	:	18 acre
Crops grown	:	Groundnut, Cotton, Onion, & Chilly
Livestock	:	Gir Cow : 3

SPECIAL RECOGNITION :

He is a progressive farmer of Rajkot district. He was inspired from Krishi Vigyan Kendra, Juangadh Agricultural University, Under NCCSD Crida by demonstration of decomposting of cotton stalk through cutting of cotton stalk into shedder. In Saurashtra region most of the cotton growers burn the cotton stalk after completion of harvest season. KVK Rajkot motivated the farmers to start decomposting of cotton stalk by cutting it into small pieces and than decompost it by using decomposer bacteria like Cylitic. for maintain soil health and sustainability. Govindbhai Pachabhai Undhad started it from this year and has produced 20 tonnes of high quality organic manure by adopting cotton stalk decomposition method. More than 35 farmers of surrounding villages of Khorana have adopted this practice by learning and believing this method and at present it spread up horizontally.

- **Vermi compost production**

Name of Farmer	**: Raghvendrashihji C. Jadeja**
Address	: Bhadva
Taluka	: Kotda Sangani
Dist.	: Rajkot
Contact Number	: 9427729201
Age	: 60 years
Education	: S.S.C.
Land holding	: 36 acre
Crops grown	: Groundnut, Cotton, Gram, Sugarcane & Anola
Livestock	: Gir Cow : 25
	Gir Bullock : 4

SPECIAL RECOGNITION :

Shri Raghvendrashinhji Jadeja is a progressive, dynamic and innovative farmer. He is a graduate and regular visitor of KVK . He is having 40 ha. of land and 29 animals with 25 pure Gir cows. He used to prepare Farm Yard Manure by traditional method. He had attended training programmes on “Organic residues management” as well as “preparation of vermi compost” arranged under KVK from campus training programme. He prepared vermi pits for composting after obtaining the guidance from the scientists of KVK. At present, he prepares 2000 kg. of vermi compost per month and selling the vermi compost at the rate of Rs. 5 per kg. and getting Rs. 10000 per month. Neighbouring farmers are also approaching him for preparation of vermi compost and many are already started the vermi composting on their farm to fulfill their own requirement.

Impact of new technology:

By preparing the vermi composting, the farmers can improve soil health and can also earn money by adopting this as a secondary agriculture business.

- **Successful Farmer:-Jamnagar district of Gujarat**

  Name : Nanjibhai and Vijyaben Akbary.

  Village : Mota Vadala, Ta. Kalawad, Dist: Jamnagar,

  State : Gujarat.

  Soil type : Coastal salt affected soils of Jamnagar district.

  Temperature : Optimum temperature required for better growth of Date palm ranging from 40 to 45º C. The temperature up to 50º C. is well suited crop for better growth and yield of the crop.

  Technology adopted - Variety: Date palm variety – Barahee having red and yellow color fruits.

  – Government assistance: 50% subsidy provided by the Department of Horticulture for procuring of date palm tissue culture plants. The price of the tissue culture plant of date palm is approx. Rs.2400 to 2500. Out of them Rs.1200 subsidy is given by the government to the farmers for procurement of plants.

  – The Barahee variety of Date palm is having small seeds and is having palatable test and produce the higher yield of the crop.

  – Cultivated area: 200 plants of Barahee variety are transplanted in 2.5 hectares of land.

  - **Methods of transplanting:**

    Dig out the 1x1x1meter size pits in cultivated land. Apply 20 kg well rotated FYM + 250 gm Trico derma + 50 kg fresh soil of ponds and refill the half pits before the planting of the tissue culture plants.

    Then transplanting tissue culture plants in pits again help to refill the whole pits and give the support by the bamboo sticks to every tissue culture plants.

    Then irrigate the crop with sufficient quantity of irrigation water after planting of the date palm plant.

    Water Management:

    Apply the irrigation as and when required the crop. Arrange the drips at spacing 4x4 feet between the two drips and run the drip as per recommendations for the better development of the plants.

    4 - Year aged plant requires 32 liters of water through the drip

irrigation. In initial stage let it run half an hour drip per day then afterwards run the drip up to the 3 hours at fruit baring stage. The Date palm crop should not require the irrigation during the rainy season.

Irrigate the crop in Rabi and hot weather season at the interval of 25 and 15 days respectively.

Other cultural operations: Cultural operations like Weeding or split application of fertilizer, inter-culturing should be carried out in time as per recommended practices.

- **Production of Capsicum through Greenhouse technology with poor quality of saline water**

Name	:	**Shri Meshbhai**
Village	:	Bhadar, Ta.: Dhangarda
Dist.	:	Surendranagar
Production	:	Red and Yellow Capsicum
Technology adopted	:	High-tech Green House

– He is return back from South Africa and left the service after seven years. He has visited many places (Himatnagar, Surat and South Africa) for information and gets the benefits of greenhouse technology.

– He is having 6.00 hectares of land for farming.

– He has only utilized 0.40 hectare land for greenhouse production of capsicum.

– Due high Total Dissoluble Salts (TDS)in irrigation water. He has refined through R.O. Plant and used for the production of capsicum.

– He has adopted fully packages and practices and produced 40 to 45 tons capsicum from his green house.

– He sold their produce in Bombay, Delhi, Ahmedabad and Rajkot market and annually he could earn worth of Rs. 20 lakhs from his green house.

– He has taken all Government benefits i.e. subsidy for making green house.

– He has planted 14,000 capsicum plants and weekly he can harvested 800 to 1,000 kg capsicum from his green house.

– He has decided to take high-tech cultivation of tomato crop after the harvesting of capsicum crop.

- **Successful Farmer of Bhavnagar district of Gujarat**

  Name : Vitthalbhai Patel

  District : Bhavnagar

  Adopted technology:

  Plantation of improved variety of Ber i.e. Gola, Nehrun and Save.

  He has planted the Ber grafted plant in 1x1x1 meter pits in July by mixing with 5 kg vermi compost + 250 gm DAP + 250 gm trico derma + 50 kg fresh soil of pond + 5 kg gypsum in each pit.

  He has planted the grafted plant of improved variety of Ber. The height of the grafted plant. Approx. 1.5 to 2.0 feet's and each grafted plant can be supported by bamboo sticks. He also carried out inter-culturing operations 2 to 3 times in a year to control the infestation of weed.

  Two splits of nitrogenous fertilizer applied @ 25 kg nitrogen per hectare.

  He sprayed Gebralic acid before the initiation of flowering to induce the higher number of flowers in Ber plants. The flowering stage occurs during the period of October to November.

- **Successful Farmer:- of Rajkot district of Gujarat**

  Name : Shri Rameshbhai Sivabhai Tarpada

  Address : Village : Jiger Pipaliya, Ta. Lodhica Saurashtra region

  Adopted innovative technology:

  Diversified farming instead of groundnut cultivation he has selected orange cultivation in his farming system.

  Details about orange farming:

  - Selected improved variety of orange for plantation.
  - Total 8000 nos. plants of orange planted at the distance of 15 x 15.
  - In advance in April mas he has dug out 2 x 2 x 2 pits for plantation purpose.
  - He has provided drip irrigation system in 100 vighas land for orange plantation.
  - All the plants of orange he removed all the extra branches, keeping

the distance of 2.5 of orange above the ground levels.

- Up to five years he has taken inter crop like cluster been, groundnut.
- He applied 15 days and 10 days interval irrigation in rabi summer season.
- He has applied 10 kg F.Y.M., 50 annum D.A.P. and 500 gram urea after the plantation of three years to each orange plant by ring method and deeply buried in soil 1 feeds away from the rout zone arias and the drench is refilled soil again.
- Yield: Commercial harvesting of orange can be done after 7th year of plantation.

• **Successful Farmer:- of Surat district of Gujarat**

Name : Dilipsinh Bahadursinh Desai (Mo. 9426883309)

Address : Amboli, Ta. : Kamrej, Dist: Surat

Adopted advance cropping system :

Plantation of papaya as a fruit crop. Instead of short duration shallow rooted crop, he has selected long duration fruit crop in his farming system.

Details about papaya cultivation:

- Planted 1.00 hector papaya fruit crop.
- Planting distance : 6’ x 6’ (Between two plants and two rows)
- Inter crop: yam (Rataru)
- Average yield : Rs. 1000/plant 1200 plants

• **Successful Farmer:- of Patan district of Gujarat**

Name : Shri Bharatkumar Ramjibhai Patel

Address : Village: Khalipur, Ta & Dist: Patan

Innovative technology adopted by the farmers

Instead of short duration seasonal crop, he selected long duration crop of Pomegranate fruit crops which is found highly remunerative as against others crop followed by the farmers.

Inter crop: In last three years farmers as taken cluster bean and Suva-Anethum Sowa as inter crop in between two rows of Pomegranate crop.

Total cultivation area: 26 vighas of Pomegranate cultivation.

Total Nos. plants: 5000 plants

Cost of Plants: Rs. 12.00 plant x 5000 plants.

- **Successful Farmer:- of Vadodara district of Gujarat**

  Name : Rathva Motesingbhai

  Address : Villege : Gudhvad Po: Gutia Ta: Pavijetpur Dist: Vadodara

  Age : 35 Years

  Use of Impro. inputs: Tissue Plants of Banana Grand T-9: No. 1370

  Benefits of the farmers: Under the NCCSD-CRIDA Project farmers of tribal belt in Pavi-Jetpur district Baroda utilize tissue culture plants for scientific cultivation of Banana.

  He is fully trained about scientific packages & practices about the Banana cultivation under the guidance of expert under the NCCSD-CRIDA programme.

- **Not hard work but required smart work with technology in Agriculture- Said Maheshbhai Young farmer**

  I shared my Experience to other farmers and insisted that the other young farmers also to continue their traditional trade .if they use technology and change the perception and see agriculture as a Business. Agriculture is a best source if we upgrade our knowledge,use technology and method on appropriate timely .Now I started to produce the vermicompost and used it for the same.

  Using Integrated technology on time

  I took the training at Junagadh Agriculture University under NCCSD-CRIDA Programme and use Farmer Guide book and adopted the new technology. Also whatever waste is available in farm I collect it and put in the pit so it's converted in the compost and now I started to use this compost as a fertilizer. I lay the compost surrounding the plant so no waste of fertilizer in monsoon it maintain the humidly in whole season. This technique is suitable and favourable in our crop and even in our land. So we continue the technology and Started to cultivate the intercrop like Bottelguard and watermelon and in this we used mulching technique-Plastic mulch- and started sawing the crop after 15th September and using drip in absence of rain water. By adopting this technique we can earn more profit.

- **Farmers - “Using tissue culture tech.”**
  - ❖ No. of Plants : 636
  - ❖ Year of planting : 2007
  - ❖ First Fruiting : 2009
  - ❖ Production : 8000 KGS
  - ❖ Second Fruiting : 2010
  - ❖ Production : 14600 KGS
  - ❖ Third Fruiting : 2011
  - ❖ Production : 22000 KGS
  - ❖ Forth Fruiting : 2012
  - ❖ Production : 36000 KGS
  - ❖ Fifth Fruiting : 2013
  - ❖ Production : 44000 KGS
  - ❖ Sixth fruiting : 2014
  - ❖ Production : 19000 KGS (no rains)
  - ❖ Seventh Fruiting : 2015
  - ❖ Production : 100 % Flowering
  - ❖ Earlier the land was barren and Agriculture become not viable & sustainable so farmer do not want to continue the farming
  - ❖ By using tissue culture
  - ❖ Average farm gate price/kg:-Rs 70.0
  - ❖ Income from Rs:- 560000 to Rs. 3080000
  - ❖ Average per Acre income RS. 44000 TO RS. 242000
- **Using traditional agriculture technique:- “Amrutpani”**
  - From beginning he do not want and do not like to use chemical fertilizer and pesticide so based on their traditional knowledge he started using “Amrutpani” –the traditional pesticide –instead of chemical fertilizer .he took the mud pot and fill with 10 litter of water. Add 0.250jiggery, Neem leaves 1 kg, AKADO- Calotropis procera (Ait.) leaves 1 kg Cowdung-1 kg Cow Urine 1 lit,Gram floor 0.250 gm. He mixture everything and keep it for 8-10 days air tight. After 10

days the solution is ready he gave the name “Amrutpani”. he used this solution from starting to end of crop cycle for cotton. Every 15 days he spray this solution and because of this the height if cotton plant is 6.5 feet and the number of ball is 245-250.Also increased the production as compare to normal production. It increased 10-12 Mann(12*20=200-240 kg) To seeing this the other farmer also started to make it and using it..Many farmers visited Arvindbhai farm .he used this solution for groundnut crop also. Especially for seed treatment for groundnut seed so none of the seed was failed and “fungus” was controlled and also he used this solution as a pesticide so he got more production and less expense.

- Also because of this “Amrutpani” the wild animals like pig and Blue bull was not entered in the crop so crop was not damaged by them. Earlier because of this type of damage the production cost is decrease and expanses is increase. If we have to prepare Amrutpani Solution –all the material are available at village level so affordable and easy accessible for all rural community of farmers. It is traditionally homemade and chemical is not used so there is no hazardous for using this.

THE WAY FORWARD

CONVERGENCE OF EFFORTS – Enabling Building of Climate Smart Farmers:

Climate Smart Agriculture is not a new concept but has been evolved as a result of complex problems arising due to climate change which can be mitigated by efforts, analysis of situation (diagnosis based prescription) and programmes that meet such requirement and flexible enough to change as per required situation. The focus have to be poor farmers and uneducated farmers, women farmers and rural youth.

The role of Public leadership is very crucial. It has promoted this as a Mass Communication and provides hand holding to farmers.

It needs changes in behaviour and strategies as well as changes in the usual timing of agriculture practices and adopting new crops / switch crops/ livestock management depending upon changes in weather pattern during season.

But there are specific areas where farmers need assistance.

Providing information to farmers:

Early Warning System

Available option: for crops based on soil health and moisture analysis, for markets – local & district. About climate – weather forecasting - long – medium – short term–day to day. This should be supported by agro – advisory.

a) Based on forecast

b) After unforeseen climate event has taken place like heavy rains and flooding of fields.

- First is need prior to commencement crop season – what they should grow – pre-kharif (monsoon) and pre – rabi (winter) based on prevailing climate parameters.
- This has to be followed by intra – weather agro advisory – based on unforeseen changes in weather during season (contingency plan).

- Finally at post-harvest stage – where they sell products or store it till the market price is improved.
- Farmer also needs to know what is market demand - both as regards to quality and in terms over all requirement and possible market price. This will enable him to grow right type of crop.
- Similar advisory is needed for livestock management and fisheries.

Hence, entire exercise is multi- dimensional and extension officer have to be trained for that. Perhaps entire extension network may have to be revamped.

There is need for Agriculture Administration to focus on poor farmers who are left out of development process. Ensure that they are guided and their progress is monitored – on case to case basis.

The other important need is of a single window to farmer to have access to government assistance wherever available.

Minimum Support Price & Procurement:

MSP needs to be communicated prior to sowing season – so that farmer knows what he will get – if market price fails him, to select his crop. Prior to harvesting details of procurement centres must be widely published. Much better and efficient way is collect it from village, make payment and charge farmers for transport cost which they will happily be paid. But farmer must be made aware that he must sell his produce to APMC and if that offers less price, to procurement centre as if he sells at village level or to a trader he looses 15% to 20% of his income-value.

Institutional Finance:

The capital investment in agriculture is increasingly on decline. There is urgent need to monitor agriculture credit and revitalize long-term investment in agriculture sector.

Reduction of Food loss:

From post harvest to market – point, farmer looses at about 15% to 25% of his produce and therefore that much income. We have organized village level collection and payment for liquid perishable milk. Same is about sugar cane – in both cases cooperatives are working efficiently –but this has to be extended to other crops – including vegetables. The Cooperation Department needs to activate itself promote new cooperative unions.

Solar Pumps:

There is need to promote farmers to use solar pumps aggressively – as described "Dhundi Model Village". State Administration can play vital role – instead of Corporate Solar Parks – solar pumps could become decentralized unit of solar park system in a farm and villages which could be connected with greed of Electricity Company. This will provide assured additional income and will be environment friendly. Same can be replicated for wind energy by setting up wind mills in farm. This needs Public-(Government and Electricity Company) – Private (Industries) – Private (Farmer) partnership.

Use Agro Waste:

There is need to support and promote use of crop-residues for vermi-compost or for industrial use. This will reduce cost of farmers and also help environment as some farmers are burning it. The State Government has to take up a Massive Programme.

CSR – of Industry:

This needs to be channelized for agriculture development. For example now insurance is available for non-loanee farmers. They are generally very poor. Under CSR their premium could be paid. Similarly soil health and water analysis – industry could be involved to set up labs and run it and provide information to farmers.

Civil Society:

We have NGOs in almost every block. Already there is some convergence but this needs to be enhanced for all above activities. At least they can work for communication to farmers about scientific agriculture and climate related advisory and also advisory based on soil health and water analysis.

Agriculture Universities:

They need to expand their horizon. It is not only crops or livestock but "Early warning system" "Salinity in water and soil, Market guidance crops selection based on soil and water analysis, new tissue –plants solar pumps-book keeping by farmers-transport and storage so on so forth keeping in view continuing changes in climate for each of all these. They need to provide prompt guidance through KVK and ATMA.

KEY RECOMMENDATIONS TO FARMERS

- Unpredictable and erratic climatic patterns resulting from climate change will affect crop production. This will have an impact on farmer livelihoods and food availability. Climate-Smart agriculture provides management options to farmers to both adapt to, and mitigate, Climate Change and maintain his income and look for opportunity to increase it.
- Crop production must adapt - crop varietal selection, plant breeding, cropping patterns and ecosystem management approaches and become resilient to changes (frequency and intensity).
- Crop production can contribute to mitigating climate change by reducing green house gas (GHG) emissions - for example by reducing the use of/judiciously using inorganic fertilizers, avoiding soil compaction or flooding to reduce methane emissions (e.g. in paddy rice systems) and sequestering carbon (e.g. planting perennial crops and grass species).
- Farmers are the primary custodians of knowledge about their environment, agro-ecosystems, crops and cropping patterns, and local climatic patterns. Adapting cropping practices and approaches will be related to local farmers' knowledge, requirements and priorities. Sustainable crop production provides farmers with options for farming sustainably, taking into account the local ecosystem and how to follow selection of crops which can be sustained by soil – based on soil health and moisture analysis of their land.
- Integrated approaches — such as crop-livestock systems, rice-fish systems and agroforestry — diversify food sources and consequently strengthen the resilience of farmers' livelihoods. They also provide opportunities for mitigating climate change but more precisely it also increase their income level and in worst circumstances maintain it.

The following suggestions are for increasing income –

- Follow drip Irrigation and Save water to take multiple crops.

- Buy only certified seeds and replace seeds
- Buy fertilizer as per recommendation in soil health card
- Select crops which is suitable to soil
- Follow weather forecast and do agricultural practices based on that only i.e. if rain is to be delayed – do not sow seed – do not spray pesticide if there is wind etc.
- Reduce cost – losses by using – green manure – use cow dung with agro-waste to make a compost.
- Follow guidance in book for post harvesting practices.
- Following guidance in book for good agricultural practices and book keeping.
- Sell you product at APMC – not to local trader or at MSP collection centre.
- Avail of all assistance available by govt.

The Government of India – Ministry of Agriculture has taken series of initiatives to assist farmers. Different Schemes are under following heads. Farmers need to apply with local office – Agriculture Extension and Village level Workers for obtaining assistance.

- Agriculture insurance : Pradhan Mantri Fasal Bima Yojana (PMFBY)
- Soil Health Card, Soil Conservation and Micronutrients.
- Irrigation : Prime Minister Krishi Sinchai Yojana and other Schemes
- Agriculture Marketing : National Agriculture Market.
- Organic Farming : Paramparagat Krishi Vikas Yojana (PKVY)
- Horticulture
- Seeds
- Mechanization and Technology
- Training and Extension for Farmers
- Agriculture Credit
- Plant Protections
- Sustainable Agriculture

The details are with local TDO/District Agriculture Office and Website of Government of India and State Government.

A WIN – WIN SITUATION

Many countries of the world experience decline in growth rate of agriculture including India. Agriculture as a profession has proved to be uneconomical due to adverse impact of climate Change. In India the average annual growth rate in agriculture sector is about 2% while that of industry sector is 8% and of service sector is 10%.

As a result the farming community is switching over from agriculture to non-agricultural activities. As per NSSO - 2005, 60% of the farmers do not like farming. Moreover, it has also resulted into migration of population from rural to urban areas.

This has created urban and rural divide. The progressive and visionary farmers are becoming richer and the small holders who remain traditional living subsistence way of life while some are committing either suicide or are embracing Naxalism.

This situation has resulted into following:

- It creates food shortage for increasing population and fodder shortage for animals and it is creating social turmoil and even inter-country migration. From neighbouring countries
- On the other side, the demand for the agro-produce and horticulture produce like fruits, vegetables, flowers, dairy products, meat is increasing. As a result the opportunities for agro-processing and value addition are increasing.
- There is need for involvement of rural youth in high-tech agriculture and agro processing micro enterprises at local level.
- There is need for involvement of Public Leadership and Sensitize them about perspective of small holders – poor farmers.
- There is need to motivate and provide Capacity Building to Poor Farmers to move up and integrate traditional methods with new perspective which can meet challenges of a severe impact.

- There is need to make Agricultural universities to provide guidance for each block and provide block specific contingency plan and to be distributed same to each village. Further all research project need to factor climate change.

The climate Smart Agriculture can convert these challenges into opportunities through creating a win-win situation, reaping benefits to all the stakeholders.

The public governance system – both elected and non-elected need to reach out to farmers and rural youth. Moreover, the natural endowment in the form of un-utilized wasteland resources and unlimited sunshine in tropical areas of our country can be used smartly. Its scientific use provides a new dimension to meet these challenges through climate smart agriculture, which is the key to sustainable development in majority of developing countries.

We do not have data about reduction in absorption of CO^2 occurred as a result of declining vegetative cover, de-forestation, decrease of area for agriculture activities, increased industrialization and urbanization and increase of fallow agriculture land due to migration to urban centres. But in reality, due to this, there is substantial reduction in natural photosynthesis process, which has increased CO^2 in the atmosphere. Unfortunately the experts of Global Warming – Whether local or international organizations have failed to take into account that industrialization – urbanization does double jeopardy – it creates – enhance GHG emissions and it stops natural GHG reduction by acquiring agricultural lands.

Further agriculture can be used as a major mitigation tool due to its photosynthesis process by which it absorbs CO^2. The vast waste lands, could be brought under vegetative cover to absorb CO^2 from atmosphere, which in turn can provide sustainable livelihood and also provide capacity to meet the challenge of food security. More importantly, it can bring back the balance i.e. the equilibrium in nature's five forces, the sky, the earth, the sun, water and vegetation – and its interaction and inter dependence and calm the unpredictable weather. This is the need of time.

Says Shri Kantisen Shroff – the veteran NGO, "the combination of photosynthesis and ability of plants to lay down Cellulose and Lignin acts as a powerful concentrator of carbon from the atmosphere into a fixed form. There is no parallel human technology that is capable of performing this kind of carbon concentration. With appropriate use of knowledge economy, several countries in the world are witnessing a decline in the growth of agriculture, especially food crops".

India’s share of arable land in the world is 11.5% (next to USA). There is scope for improving the yield of major crops. India’s yield per ha. is reasonably high as compared to world average estimates. In some major crops it is: paddy – 75%, wheat – 65%, Cereals – 73%, Pulses – 79%, Soya – 48% and Maize – 38%. In cotton seeds, we have reached the world’s highest yield with BT cotton seeds. We need to first reach the world average and then the world’s highest yield in all crops. This is possible as India has rich experience of not only adverse climatic conditions but its some farmers producing their crops equivalent to or higher than the world standards. It has rich pool of agricultural scientists and educated young farmers. But the fruits of success lie only in pockets. It has to be uniformly spread over entire length and breadth of country to each of its village and for that responsibility lies with its Public Leadership. We can together make this happen thereby creating a win- win situation. For creating that situation and doubling farmers’ income the key is to have Climate Smart Farmers. The farmer who is himself aware of change – challenges – opportunities that exist and willing to adapt and make himself economically prosperous while contributing to ‘Food Security’ .

This can be achieved. The Global Warming which is a threat and can be converted into an opportunity. It is possible to make happen a win-win situation for all, channelizing all efforts of each stackholder for sustainable development with Greener Agriculture at its centre. The unique aspect of this initiative is that it has to be a mix of top-down and bottom-up approach and using modern technology with information communication techniques adapted to local needs – irrespective of the fact they may differ from tehsil block to tehsil block or even from village to village. A locally developed acceptable Action Plan based on all different dimensions with farmers will be at a central action point.

The key to meet the challenge of Global Warming is LEADERSHIP, which has to become motivated and committed for the promotion for sustainable development through Greener Agriculture. It needs to have goal and role clarity, adopt detailed planning and implement the strategy based on knowledge economy.

The leadership at all levels - village, taluka, district, state and centre. The Chief Ministers and even Prime Minister. This includes: Non elected leaders, owners entrepreneurs, managing directors of companies, NGOs, civil servants, VLW, Taluka Development Officer (TDO), Collector and the Chief Secretary of State Governments and Cabinet Secretary of Union Government, the educational leaders (teachers, research scientists, Vice Chancellors and students), the spiritual leaders and the international organizations.

Such transformation meets the challenges of poverty and Global Warming which seems to be insurmountable. A cohesive action with a common goal in mind can lead us to comprehensive prosperity. It can achieve multiple goals – social, economic and environmental sustainability at a time and double income of farmers, meet the food security of growing population.

Countries-Governments-all over the world will have to view the impact of Climate with grave concern, the Change which is creeping in rapidly-with dangerous consequences to habitat - its stability. This modern war is on “Nature’s Front” and nuclear weapons or army is no solution. The solution lies in bringing back balance in nature’s forces: the atmosphere, the sun, the earth, the water and vegetation. The solution lies at local level. Our endeavor is to overcome these challenges and convert it into an opportunity and the present Guidebook is a means to achieve these – it is meant for all stakeholders.

ACRONYMS

- AAU : Anand Agricultural University
- AC-ABC : Agri Clinics & Agri Business Centre
- AP : Andhra Pradesh
- APMC: Agricultural Produce Market Committee
- ATMA : Agricultural Technology Management Agency
- B. Sc. : Bachelor of Science
- B. Tech. : Bachelor of Technology
- B. V. Sc : Bachelor of Veterinary Science
- BPL : Below Poverty Line
- BRS : Bachelor of Rural Studies
- BT Cotton: *Bacillus Thuringiensis Cotton*
- CRIDA : Central Research Institute for Dryland Agriculture
- CSA : Climate Smart Agriculture
- EKW: East Kolkata Wetlands
- FAO : Food & Agriculture Organization
- GHG : Green House Gases
- GM :Genetically Modified
- ICAR : Indian Council of Agricultural Research
- ICRAF : International Center for Research in Agroforestry
- ICT : Information and Communications Technology
- IMD : India Meteorological Department
- INM : Integrated Nutrition Management
- IPCC :Intergovernmental Panel on Climate Change

- GACSA : Global Alliance on Climate Smart Agriculture
- IPM : Integrated Pest Management
- ISFM :Integrated Soil Fertility Management
- ISPL : International School for Public Leadership
- ISRO :Indian Space Research Organization
- IWM : integrated Weed Management
- KE :Knowledge Economy
- KVKs: Krishi Vigyan Kendras
- M. V. Sc : Master of Veterinary Science
- MAOs
- MP: Madhya Pradesh
- NAREGA : National Rural Employment Guarantee Act
- NCCSD :National Council for Climate Change, Sustainable Development and Public Leadership
- NGOs :Non Government Organizations
- NICRA : National Initiative on Climate Resilient Agriculture
- NSSO : National Sample Survey Organization
- NW : North West
- PPM
- PPP : Public Private Partnership
- RADP: Rainfed Area Development Programme
- RCTs : Resource Conserving Technologies
- RKVY :Rashtriya Krishi Vikash Yojana
- RLF : Revolving Fund
- SAFE: South Asian Forum for Environment
- SAUs: State Agricultural Universities
- SHGs :Self Help Groups
- SOM : Soil Organic Matter
- SRI : Systems of Rice Intensification
- TDO: Taluka Development Officer
- VLWs : Village Level Workers
- VRTI : Shree Vivekanand Research & Training Institute, Kutch, India
- FAMU : Florida Agricultural & Mechanical University

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NATIONAL COUNCIL FOR CLIMATE CHANGE, SUSTAINABLE DEVELOPMENT AND PUBLIC LEADERSHIP

National Council for Climate Change, Sustainable Development and Public Leadership (NCCSD) is a non-profit organization. It aims to facilitate and carry out appropriate and target oriented action for climate change mitigation and adaptation; interlinking agriculture, sustainable development and rural development. Foster and leverage public leadership to achieve the goals of such an integrated approach ; & strengthen knowledge economy.

The Council is registered as a Charitable Trust with the Charity Commissioner, Gujarat. Its Chairman is Hon'ble Justice B P Singh, formerly Judge, Supreme Court of India. Sarvshri Dr. M. S. Swaminathan, Shri Kantisen Shroff and Dr. Y. S. Rajan, are the patrons of the Council. Dr. Kirit N Shelat, IAS (Retd) is the Executive Chairman.

- Is has Consortium of 12 NGOs. Know as Shroff - Consortium. It is working in 2000 villages with 300000 farmers in Gujarat and Maharashtra. This has a team of 600 filed level workers.
- NCCSD is think-tank organization and working with agriculture & related Departments of government, Agriculture Universities and more particularly with community leaders to build climate smart farmers in area of climate change.

- NCCSD is promoting Sustainable and Climate Resilient Agriculture with the involvement of Public Leadership. NCCSD is accredited organization with The United Nation Framework Convention on Climate Change (UNFCCC). Global Alliance on Climate Smart Agriculture GACSA-FAO, Green Climate Fund-GCF, Climate Technology Centre & Network (CTCN), APN South Asia-APN, Central Research Institute for Dryland Agriculture (CRIDA), NITI Aryog.

NCCSD is based at Ahmedabad, Guajrat (INDIA)

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BOOK OF SAME AUTHOR
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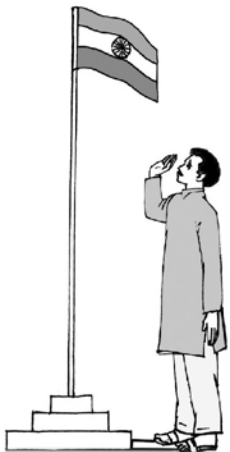
Be a Climate Smart Farmer



Alert on Weather changes-During season

Select crop based soil health and water analysis

Use Certified Seeds and Tissue Culture Plants

Use drip irrigation and go for multiple crops.

Reduce loss in post harvest and transport to market

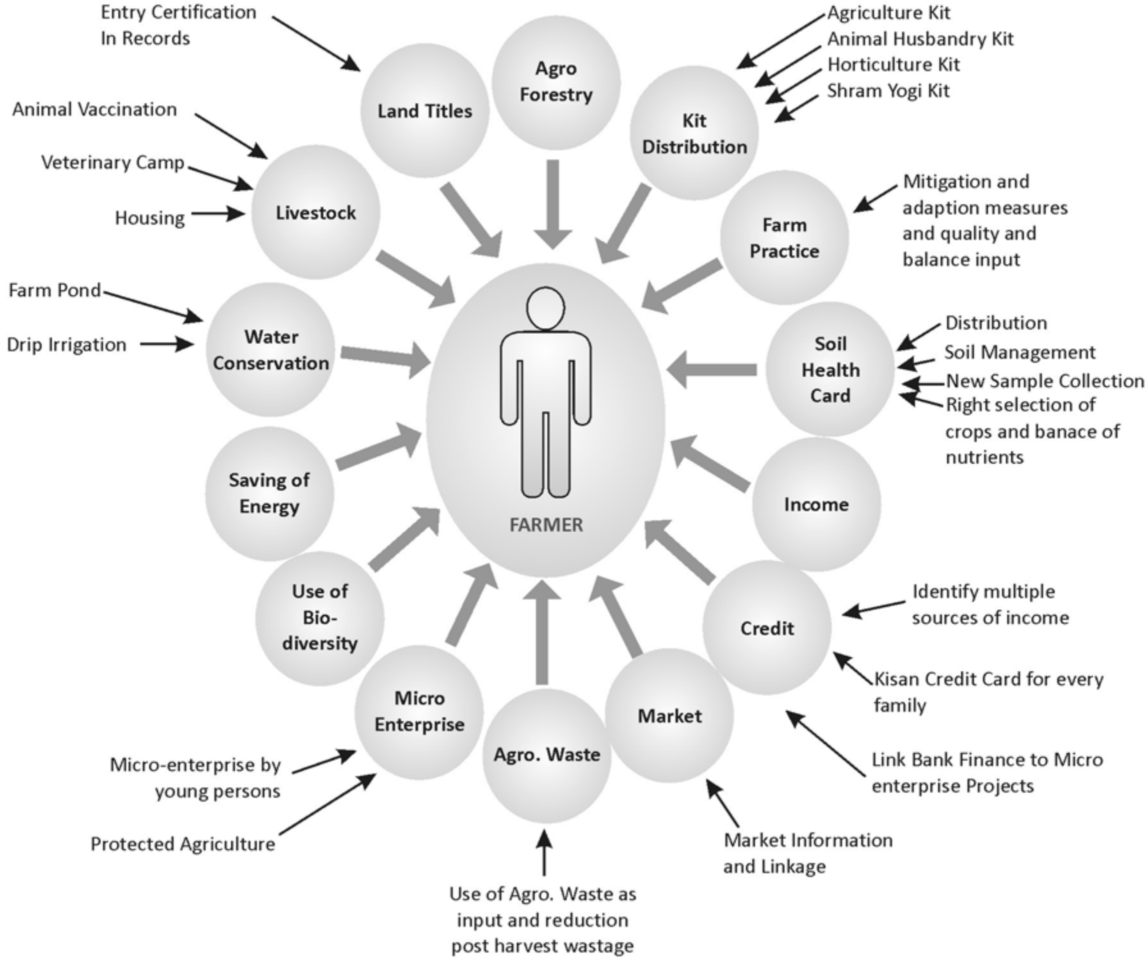
Avail govt. subsidy where available

Sell only at APMC or MSP collection Centre

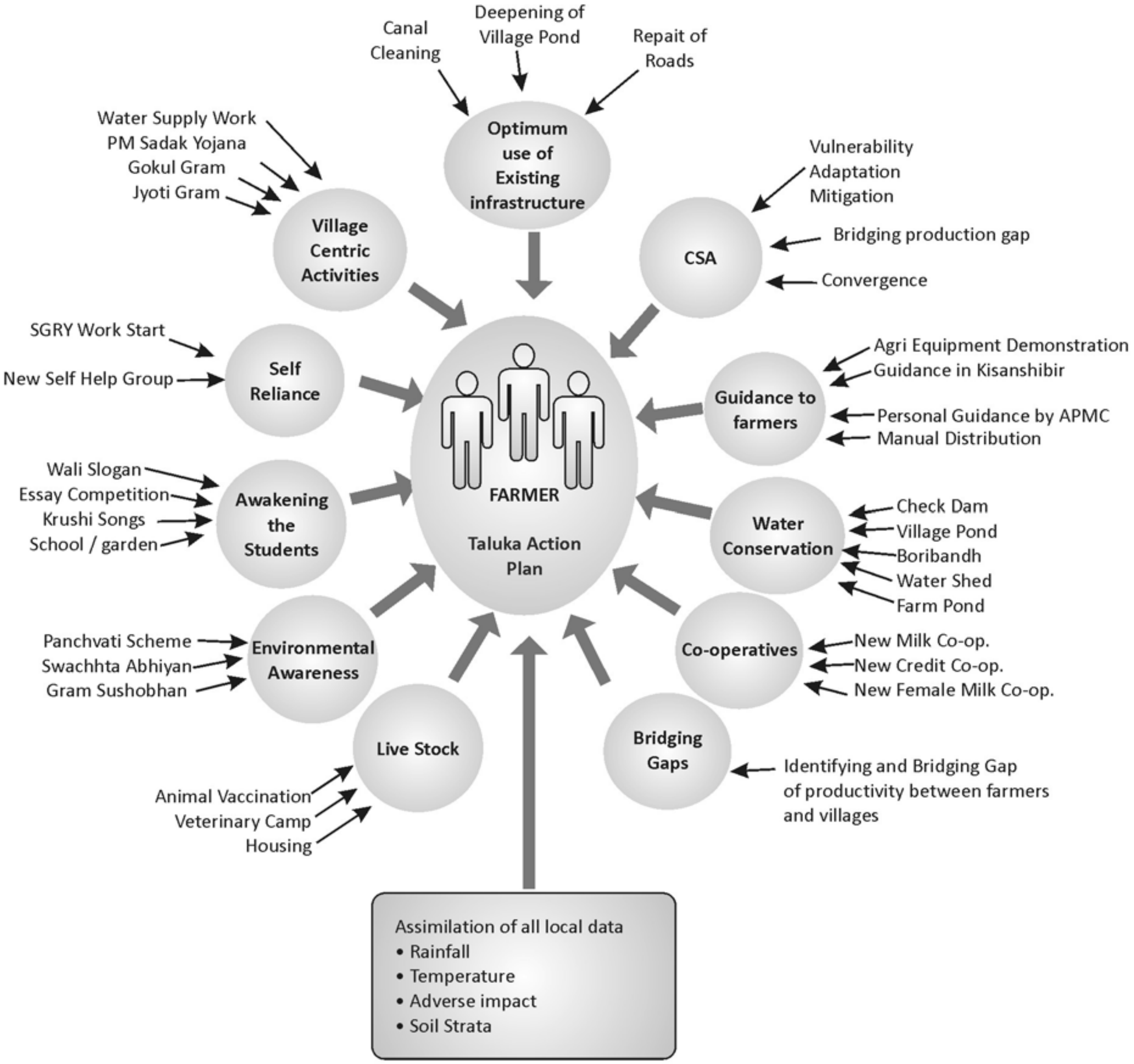
Have Multiple Source of Income

Have goal of increase in income

Climate Smart Agriculture



Taluka Action Plan



Atharvaveda Hymn LXVII

१. पश्येम शरदः शतम् ॥

1. May we see for hundred years. (4960)

२. जीवेम शरदः शतम् ॥

2. May we live for hundred years. (4961)

३. बुध्येम शरदः शतम् ॥

3. May we acquire knowledge for hundred years. (4962)

४. रोहेम शरदः शतम् ॥

4. May we go on prospering and progressing for hundred years. (4963)

५. पूषेम शरदः शतम् ॥

5. May we go on being nourished for hundred years. (4964)

६. भवेम शरदः शतम् ॥

6. May we remain strong and sturdy for hundred years. (4965)

७. भयेम शरदः शतम् ॥

7. May we retain our prestige and influence for hundred years. (4966)

८. भूयसीः शरदः शतात् ॥

8. May we retain all these powers of sight etc., for greater numbers of years than hundred. (4967)

** Compiled by Dr. R.S. Rajan, Distinguished Professor, ISRO*

A NOTE FROM PUBLISHER

This book authored by Dr. Kirit N. Shelat & Co-authored Dr. Odemari Mbuya is the need of our time & we are happy to bring out this book. In fact the book is in response to call given by our beloved Prime Minister Shri Narendra Modi to "Double the Income" of farmers despite adverse impact of climate change.

We are associated with NCCSD and its Executive Chairman – Dr. Kirit Shelat since long and happy to contribute the efforts to make our Farmers Smart to meet the challenges of climate change by publishing this book. The climate change is affecting the entire habitat and as a concerned citizen we all need to be aware of how these changes are affecting our day to day life and what we should do about it. The farmers – suffer most – as its impact at village level is maximum, it results into crop – failure or less production. We have published and supported earlier versions of these guidebooks in Gujarati and Hindi.

In fact we have published almost all books written by Dr. Kirit Shelat who has after retirement as Principal Secretary – Agriculture, continued his mission to promote sustainable livelihood for farmers and we are proud him. The present book is jointly authored – the co-author is distinguished American Scientist – Dr. Odemari Mbuya from Florida Agriculture and Mechanical University – Florida – USA.

We are sure this Guidebook would help farmers of not only our country but of entire developing world.

Shreyas V. Pandya
Director
Sahitya Mudranalaya Pvt. Ltd.

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