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Climate smart agriculture
The way forward
The Indian perspective

Kirit N. Shelat

Executive Chairman - NCCSD, Patel Block, Rajdeep Electronics Compound, Stadium Six Road, Navrangpura, Ahmedabad – 380014, India
Email: drkiritshelat@gmail.com

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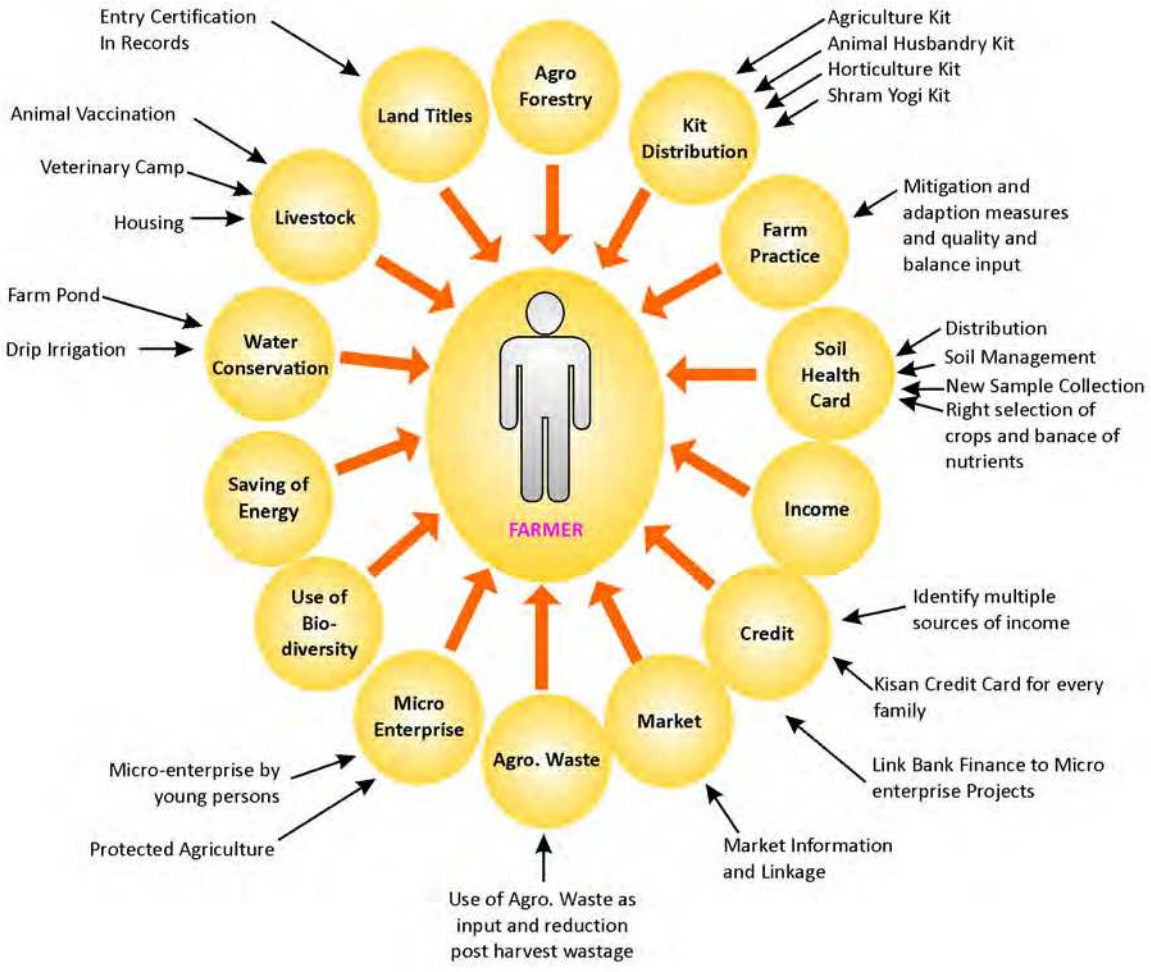
CLIMATE SMART AGRICULTURE

THE WAY FORWARD

THE INDIAN PERSPECTIVE

DR. KIRIT N. SHELAT

Climate Smart Agriculture



CLIMATE SMART AGRICULTURE
THE WAY FORWARD

The Indian Perspective

EDITED BY
DR. KIRIT N. SHELAT

CLIMATE SMART AGRICULTURE – THE WAY FORWARD
THE INDIAN PERSPECTIVE

Editor
DR. KIRIT N SHELAT

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DR. KIRIT N SHELAT, IAS (RTD)
Executive Chairman - NCCSD,
Patel Block, Rajdeep Electronics Compound,
Stadium Six Road, Navrangpura, Ahmedabad – 380014
Email: drkiritshelat@gmail.com

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DEDICATED TO

Hon'ble Prime Minister of India **Shri Narendra Modi**
who introduced Climate Smart Agriculture concept through
the "Krishi Mahotsav" model in Gujarat

FOREWORD

Climate Change poses the greatest challenge to sustainable agriculture and food security in the coming decades. I am therefore happy that a comprehensive publication has been prepared by Dr Kirit N Shelat on Climate Change mitigation and adaptation. 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 farmers from the impact of Climate Change. Dr 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 hope the book will be widely read and used by professionals, policy makers and the public.

Prof. M S Swaminathan

PREFACE

Greetings from National Council for Climate Change, Sustainable Development and Public Leadership (NCCSD). This is an endeavour to bring out a comprehensive view on impact of climate change and how to go about Climate Smart Agriculture based on our own and international experiences.

First of all, I take this opportunity to congratulate the Director General, FAO for bringing focus on Climate Smart Agriculture and producing a comprehensive Resource Book on that. We have adapted parts of this book for Indian conditions.

In fact, National Council for Climate Change, Sustainable Development and Public Leadership (NCCSD) was set up with the precise objective of promoting sustainable livelihood with the involvement of leadership for farmers in the arena of Climate Change. In last two and half years, it held number of Seminars, Think Tank meets, National and International Conferences and series of interactions with farmers 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 climate change. India's development administration, agri scientists and civil society members have worked hand in hand with them 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 us to meet food scarcity problem. We are aware that country depended on imports of wheat in initial years and today we are the exporter of wheat.

In the present era, climate change has brought out new and difficult challenges. They need careful understanding of its impact and way-out.

Farmers need to understand them and adapt to new strategy. This is difficult but not insurmountable task. However, this will need considerable efforts on the part of all stakeholders. Challenges are of diverse nature and are un-predictable but with the experience of our farmers and expertise of our scientists, it is possible to make agriculture smarter. This book depicts how this can be done.

Ahmeddabad **DR. KIRIT N SHELAT**

21st October, 2014

ACKNOWLEDGEMENT

First of all our gratitude is to our beloved scientist Prof. M. S. Swaminathan who has encouraged us by writing the foreword. His efforts have paved way for sustainable agriculture in our country.

Our grateful thanks are to the eminent International Scientists who have put together a very useful Resource Book on Climate Smart Agriculture under leadership of the Director General, FAO. We have taken many ideas from that "Verbetum".

Thanks are due to Dr. Mayur Vyas, formerly Managing Director of Sabarkantha District Milk Union Federation for developing strategy for Livestock Management including fisheries, Dr. R. H. Patel worked on module of Contingency Plan which can be adopted in any block and to Dr. I. R. Rathod, Dr. D. R. Patel, Dr. Sherasiya, Dr. Arunachalam, Dr. J. C. Dagar and others who have contributed in one way or the other.

Ms. Hetal Seju worked on the basic manuscript and editing it.

Dr. S. Ayyappan, Director General of Indian Council of Agricultural Research (ICAR), Dr. Maheshwari - Principal Investigator and Dr. Ch. Srinivasa Rao Director of Central Research Institute for Dryland Agriculture (CRIDA) have encouraged us by providing valuable inputs and supporting publication of this book.

I express my deep sense of gratitude towards all the distinguished scientists & Vice Chancellors of State Agricultural Universities - Dr. A. R. Pathak, Dr. N. C. Patel, Dr. A. M. Shekh, Shroff Foundation Trust, Shree Vivekanand Research & Training Institute, Vigyan Prasar who strengthened overall perspective on Climate Smart Agriculture aspects.

I sincerely thank Shri Shreyasbhai Pandya of Sahitya Mudranalaya, Ahmedabad who readily extended support in putting this book together well on time.

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

I am 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.

DR. KIRIT N SHELAT

Content

Background

Approaches to Climate Smart Agriculture

The Support Activities

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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 simnlteneously it 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, un-timely 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.

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 vaccum at the bottom still remains unaddressed. Only chosen few are benefited while the majority are left out of development process inspite 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

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 microenterprise 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.

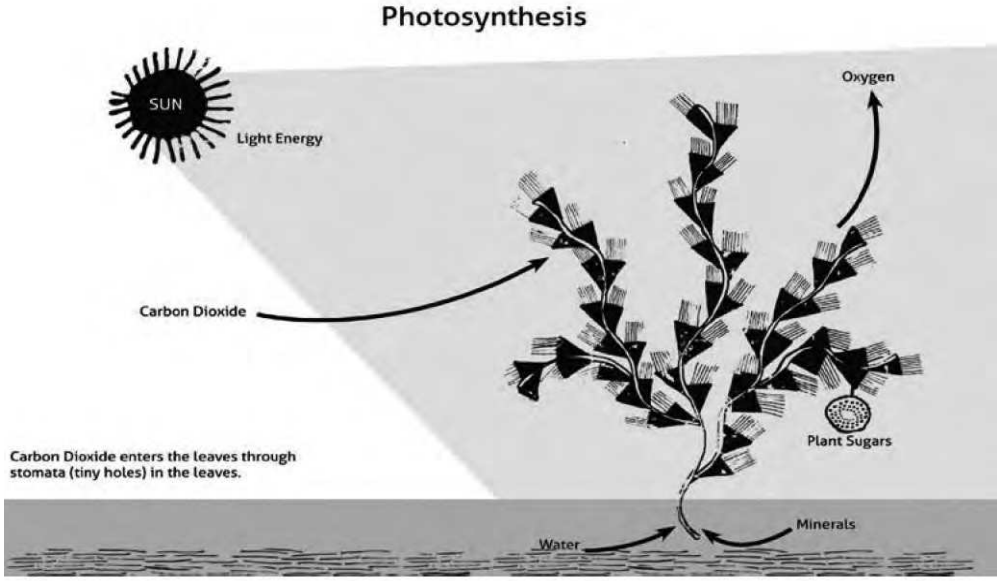
Climate smart agriculture involves :

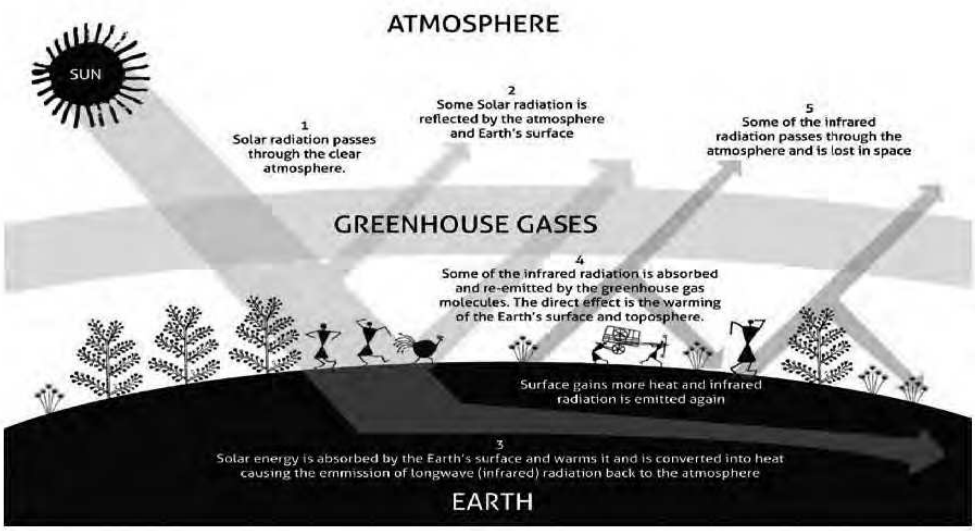
- Crop pattern based on soil health & moisture analysis to support crops which can be sustained.
- Agro – advisory

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
Plant Sugars
Carbon Dioxide enters the leaves through stomata (tiny holes) in the leaves.
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 troposphere.
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

IMPACT OF GLOBAL WARMING

We are familiar with the fact that our earth is heated by sunlight. Most of the sun's energy passes through the atmosphere, to warm the earth's surface, oceans and atmosphere. However, in order to keep the atmosphere's energy budget in balance, the warmed earth also emits heat energy back to space as infra-red radiation. A natural system known as the "greenhouse effect" regulates temperature on Earth. Just as glass in a greenhouse keeps heat in, our atmosphere traps the sun's heat near earth's surface, primarily through heat-trapping properties of certain "greenhouse gases".

Over the past thousands of years the amount of greenhouse gases in our atmosphere has been relatively stable. A few centuries ago, their concentrations began to increase due to the growing demand for energy caused by industrialization and rising populations, and due to changing land use and human settlement patterns. The greenhouse effect refers to the change in the steady state temperature by the presence of gases that absorbs and emits infra-red radiation. The greenhouse gases trap heat within the troposphere. The gases are water vapor, carbon dioxide, ozone, methane, nitrous oxide and chlorofluorocarbons.

Nitrogen, oxygen and argon make up 98% of the Earth's atmosphere. But they do not absorb significant amounts of infra-red radiation and thus do not contribute to the greenhouse effect. Carbon dioxide (CO_2) constitutes about 72% of total GHG and contributes the bulk of radioactive forcing.

Increase of burning of fossil fuel like coal, oil, gas and also wood etc caused by industrial activities and deforestation have increased its concentration in the atmosphere. The concentration of carbon dioxide (CO_2) in the atmosphere has increased from 285 ppm at the end of the nineteenth century before the industrial revolution, to about 385 ppm in the new millennium.

Climate Change is caused by Natural Forces and Human Oriented Activities

Methane is produced when vegetation is burned, digested or decayed with no oxygen present. Garbage dumps, rice paddies, and grazing cows and other livestock release methane.

- Nitrous oxide is released when chemical fertilizers are used in agriculture.
- Other gas is SF-6.
- Most interesting part of these major emitters is CFC12 ÷ 1 unit = 7000 CO_2), SF6 (1 SF = 23900 CO_2) are largely from industrialized nationals.

GHG emission is also common through agriculture activities by the use of fertilizer, methane from cow dung or rice fields. But while calculating actual emissions from agriculture – no deduction are considered to the gases that each crop absorbs. Every crop, plant, tree or grasse absorbs CO2 and releases oxygen.

Some examples are as under :

Carbon storage (t/ha) of different crops

No.	Crops	Aboveground	Belowground	Total
1	Cabbage	2.51	0.22	2.73
2	Brinjal	3.23	0.37	3.6
3	Coriander	0.8	0.07	0.86
4	Sugarcane	8.51	2.93	11.44
5	Spider lily	4.8	1.54	6.36
6	Grass	1.35	0.25	1.6

Carbon sequestration by some grains (t/ha)

	Grain	Straw	Aboveground	Belowground	Total
Wheat	0.91	1.3	2.155	0.286	4.596
Maize	1.1	1.98	3.08	0.4356	6.5956
Rice	0.85	1.2	1.9	0.264	4.064

Carbon Storage Per ha

Crops	Grain/Seed carbon ton/ha only
Castor	924.6
Soyabean	372.6
Cotton	313.0

Source: Dr. Sumankumar Jha, College of Agro Forestry,
Navsari Agriculture University, Navsari, Gujarat, India

The carbon storage is evident and significant across annuals to perennials and would serve as a classical example of w/w situation.

Rice Cultivation: Facts on Sequestering CO_2

- Rice cultivation is both an important sequestration process of CO_2 from the atmosphere and an important source of GHG emission
- For example, the global paddy rice output was 607.3 mt at 14% moisture content in 2004
- At the grain/straw ratio of 0.9 for most currently planted rice varieties, the global rice straw output in 2004 was about 676 million tonnes at 14% moisture content

- This means that in 2004, rice sequestered about 1.74 billion tonnes of CO_2 from the atmosphere to produce about 1.16 billion tonnes of biomass at 0% moisture content emissions
- Rice crops acts a sink for CO_2

As per research study by Dr. Bhatt of Central Arid Zone Research Institute ICAR Carbon sequestration in Silvipasture Systems in rangelands (after 4 years) is as under :

Systems	Total carbon Sequestration (vegetation + soil) Mg carbon ha
Panicum maximum	32.29
Cenchrus ciliaris	28.62
Stylosanthes hamata	14.74
P. maximum + S. hamata + Leucaena leucocephala	46.17
P. maximum + S. hamata + Grewia optiva	41.40
C. ciliaris + S. Hamata + Dalbergia sissoo	36.68
C. Ciliaris + S. hamata + Acacia tortilis	36.76

Compared to such important role of mitigation by agricultural/vegitation, the industries, mines, the expanding urban areas are net emitter of GHG and create double adverse impact

- They reduce agriculture areas, forests – which have been absorbing CO_2 and that stops. It is not calculated how much such reduction in removal - absorbtion of CO_2 takes place and this is not added to their accounts
- They directly emanate GHG by their working process

Hence, agriculture can play key role as a major mitigation tool by expanding area under agriculture. It must be mentioned that in current scene as per Pandits, of IPCCC agriculture's contribution in absorbing CO_2 is totally disregarded by some formula – which needs to be challenged by agri scientists to put things in proper perceptive and in a truthful manner.

THE IMPACT ON INDIA

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.

Global Impact:

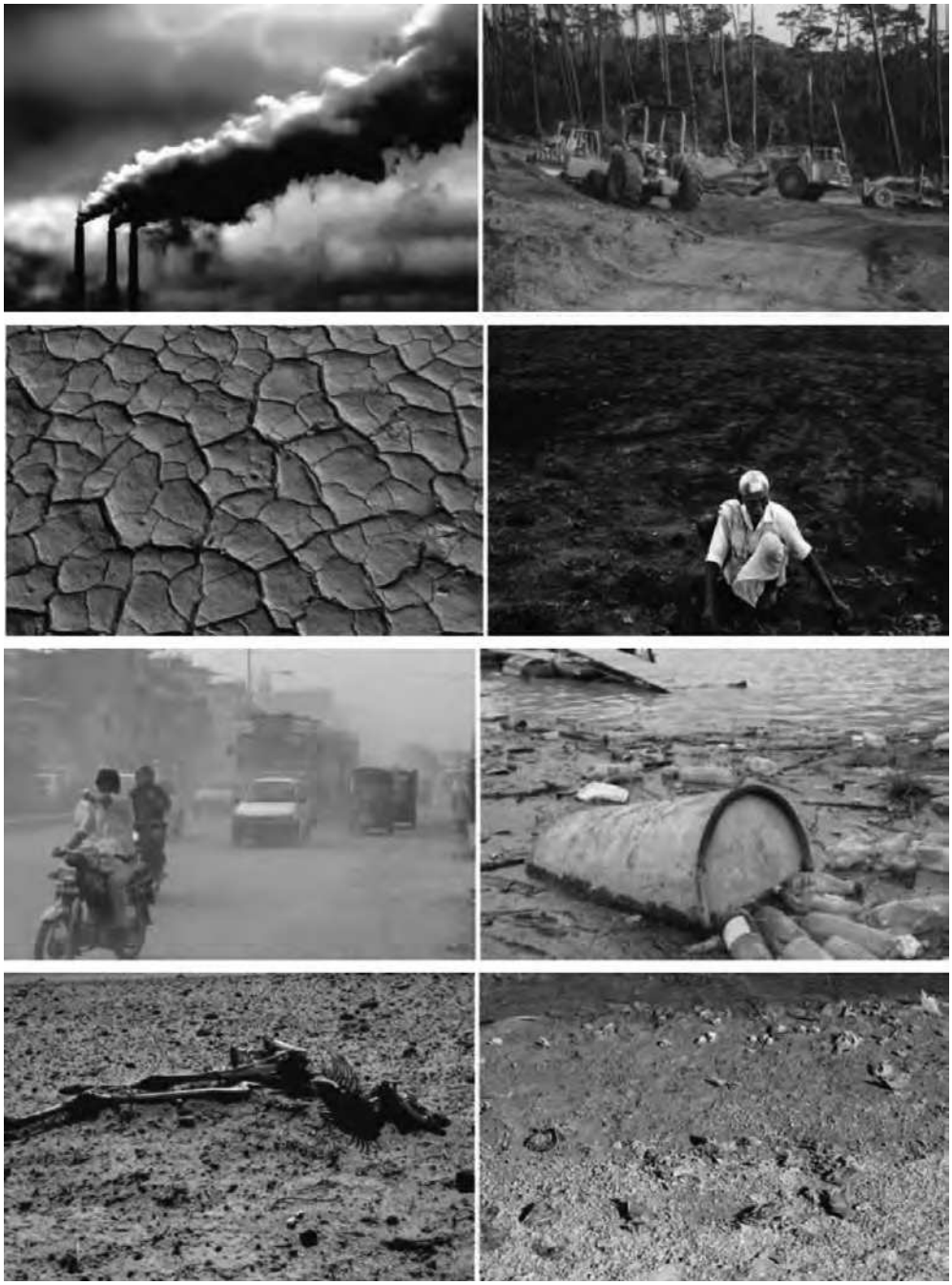
The worldwide impact is equally grave.

- 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.

Such impacts create:

- Severe famine or heavy floods
- Loss of life
- Loss of agriculture crops and animals

Effects of Climate Change



- 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.

Current Indian Scenario

Dr A. K. Singh, Formerly, Deputy Director General of Indian Council of Agriculture Research has analyzed the overall Indian scene.

- No significant change in monsoon rainfall at All India level, some regional variations are noticed
- Increase in rainfall in west coast, north AP and NW India, decreasing trend in east M.P. and adjoining areas
- Increase in surface air temperature by 0.51^0 C during 1901-2007, accelerated warming during 1971-2009
- Mean temperature rise by 0.2^0 C per decade during 1971-2009, greater rise in minimum temperature than maximum
- One day extreme rainfall events are increasing
- Cyclonic storms in Bay of Bengal showed declining trend of 2 cyclones/ decade during 1891-2008
- Deglaciation in the Himalayas
- Sea level rise in Indian Ocean 1.63 mm/year during 1993-2009

Indian Scenario: Future Projection

- Change in rainfall pattern by the end of the 21st century
- Increase in temperature by 2 to 4 0C
- Warming will be more pronounced over most of the land areas
- Maximum increase over northern India
- Relatively greater warming in winter and post monsoon seasons
- Frequency of cyclones during post monsoon seasons (2071 to 2100) is projected to much higher than baseline scenario (1961-1990)

Impact of Climate Change on Water Resources in India (2100)*

Region/Location	Impact	Reference
Indian sub-continent	Increase in monsoon and annual runoff in the central plains No substantial change in winter runoff Increase in evaporation and soil wetness during the monsoon and on an annual basis	Lal and Chander, 1993
Orissa and West Bengal	One-meter sea level rise would inundate 1700 km2 of prime agricultural land	IPCC, 1992
Indian coastline	One-meter sea level rise on the Indian coastline is likely to affect a total area of 5763 km2 and put 7.1 million people at risk	JNU, 1993
All India	Increase in Potential evaporation across India	Chattopadhyay and Hulme,1997
Central India	Basin located in a comparatively drier region is more sensitive to climatic Changes	Mehrotra, 1999
Kosi Basin	Decrease in runoff by 2-8%	Sharma et al, 2000, a,b
Southern and Central India	Soil moisture increase marginally by 15-20% in monsoon months	Lal and Singh, 2001
Damodar basin	Decreased river flow	Roy et al, 2003
Rajasthan	An increase in Earth temperature	Goyal, 2004
River basins of India	General reduction in the quantity of the available runoff, increase in Mahanadi and Brahmini basin	Gossal and Rao, 2006
River basins in north west & central India	Increase in heavier rainfall and reduction in number of rainy days	Singh et al, 2008

***** *Dr. A.K. Singh – formerly Deputy Director General, ICAR*

Observed Impacts on Agriculture in India

- Drought in 2002 reduced 15 million hectares of the rainy-season crops and resulted in a loss of > 10% in food grain production. Last year/ 2013, delayed monsoon rains caused reduction under rice cultivation.
- Terminal heat stress is lowering yields of late-sown wheat yields
- Cold waves during December 2002-January 2003 caused significant impact on crop production in northern India (mustard, mango, guava, papaya, brinjal, tomato and potato).
- Cold wave during 2006 damaged 50-60 % of young and 20-50 % of old trees of mango.
- Other fruit crops like guava, aonla, banana, papaya, bael, karonda, chironji, khirni, mahua, tamrind, wood apple and jamun were also affected.
- High rainfall in 1998 & 2005 (> 1500 mm) affected kharif and late kharif crop of onion and spoiled rabi nursery leading to price hike.
- In cashew, untimely heavy rain in March 2008 in west coast reduced the yield and nut quality.
- Shift in apple cultivation to higher elevations due to non fulfillment of chilling requirement
- Rise in sea surface temperature (2-2.5^{o}C) in May 1998 led to bleaching in 85% coral reefs.
- Extension of northern boundary of oil sardine due to rise in sea surface temperature

Heat Waves

Andhra Pradesh : *20 lakhs birds died in May & June 2003*

Continuous higher temperatures during critical growth stages of rabi crops reduces the crop yields considerably

Live stock : Heat wave can reduce a milk yield by 10-30% in first lactation and 5-20% in second and third lactation periods in cattle and buffaloes. It also affects the growth, puberty and maturity of crossbreed of cows and buffaloes

Fish : Mortality of fishing in shallow water ponds and reduction in fish catch in the water bodies due to movement of fish into the deeper layers.

Rising trends in minimum temperature during *kharif* season have negative impact on rice yields.

About 278 districts exhibited a negative impact of rising temperatures and 59 of them showed statistical significance.

Negative impacts are noticed mostly on the eastern parts, Madhya Pradesh and in Indo-Gangetic Plains.

In the current year as of September 2014 the impact of climate chage is;

- Parts of north and east India face drought
- Punjab and Haryana farmers are worried over torrential rains. All major kharif crops - paddy, including basmati - cotton and maize are in danger. In neighbouring Haryana, cotton arrivals are on. In mansa, canals have breached and about 10,000 acres of cotton crop are flooded. “Heavy rain damaged the cotton flower, which resulted in losses.

UP : Small farmers stare at big losses

Monson delay has pushed 20 of the 75 districts to the brink of drought. Worst-hit are Meerut, Kanpur and Varansi. Where dry spell has damaged paddy.

Bengal: Pockets of some districts take a hit

Unusual rain has harmed Bengal parts of Bankura, Purulia and East Midnapore have been affected.

Odisha : Large-scale flooding, minimal loss

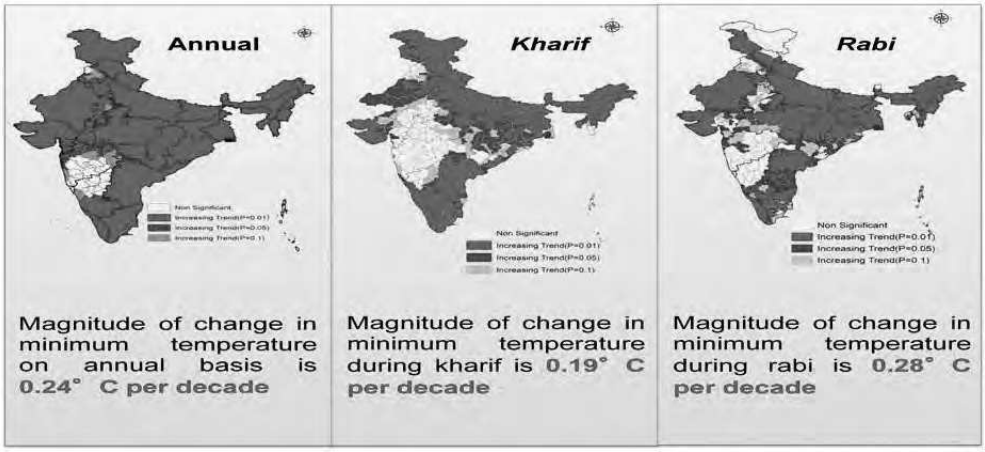
Heavy rain followed erratic monsoon and floods affected 23 districts.

Kasmir - heavy flood have affected entire region. Source : Economic Times, 7 September, 2014

But we can and have to meet these challenges.

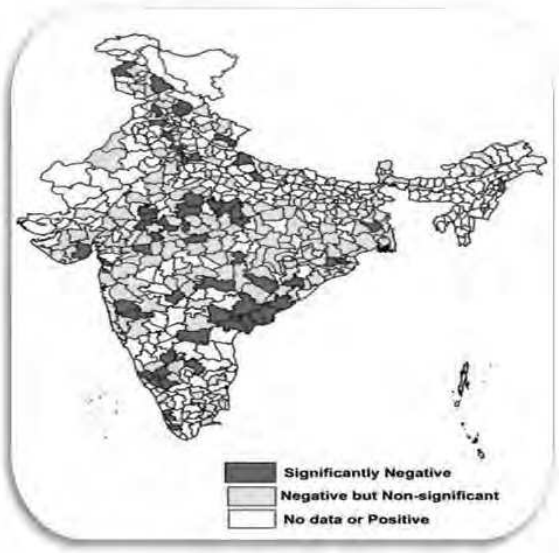
Minimum temperature trends accross India (1971-2009)

Source: CRIDA, Hyderabad



Source: CRIDA, Hyderabad

Minimum temperature and rice yields



Source: CRIDA, Hyderabad

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 creates 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 in three ways :

- first is the actual increase frequency 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.
- And third is unforeseen changes in weather during seasons.

We need to take preventive steps in this area and it can certainly be managed by timely action, convergence of efforts and with involvement of local level leadership of all stakeholders. By leadership, we do not mean only political or elected leaders. It includes all members of Public Governance System – 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.

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

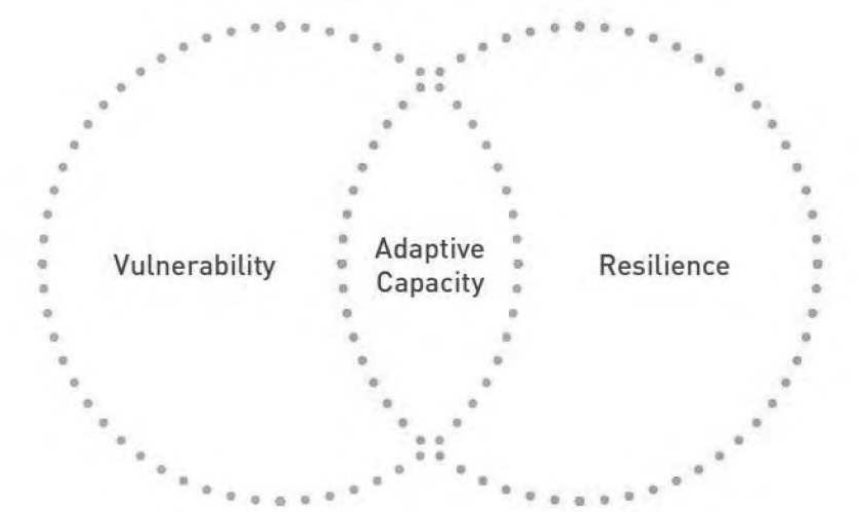
- More frequent years with above monsoon rainfall and year with extremely difficult rainfall is projected.
- An increase in the periodicity of rainfall, with more rainfall during number less number of days.
- An increase in number of precipitation events.

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 sensiticed 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

EXAMPLES OF PROJECTED CLIMATE CHANGE IMPACTS ON CROP PRODUCTION

Event	Potential impact
Cold periods becoming warmer and shorter - days and nights becoming hotter	Increased yields in colder environments; decreased yields in warmer environments; increased outbreaks of new insect pests and pathogens; potential impacts on crop production
Heavy precipitation events increasing frequently	Damage to crops; soil erosion; inability to cultivate land owing to water logging of soils
Drought-affected area increases (*likely*)	Land degradation and soil erosion; lower yields from crop damage and failure; loss of farm land
Intense tropical cyclone activity increases (*likely*)	Damage to crops
High sea levels increase in incidence (*likely*)	Salinization of irrigation water, estuaries and fresh water systems; loss of farm land

Source: adapted from IPCC, 2007, in FAO, 2008a

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 reduce also "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 (Kutch District)	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

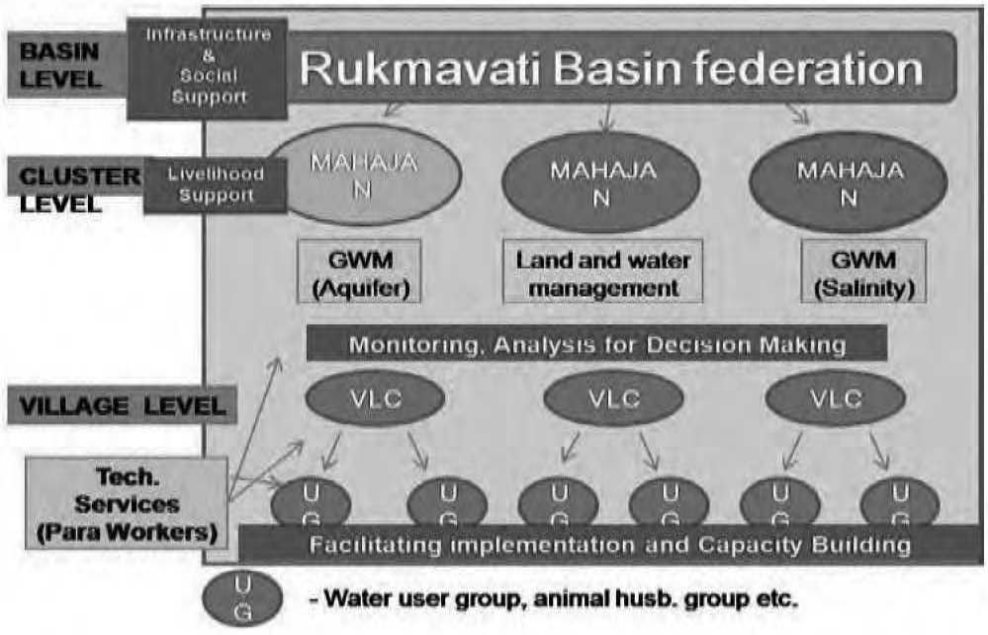
Case study of intigrated River Basin Management in Arid area.

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

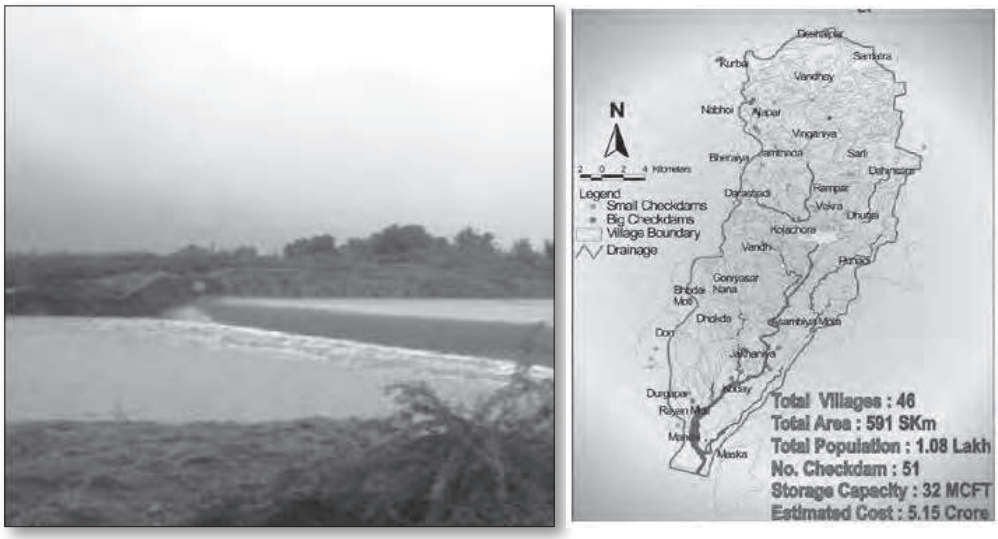
The main concern is depletion of water resources. The Integrated River Basin Management is an approach to meet this challenge. A step ahead of the existing watershed approach, it is a process of co-ordinating conservation, management and development of water, land and related resources and agro industries 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 perons 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 - 2014

- 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 op 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 pastureland 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.

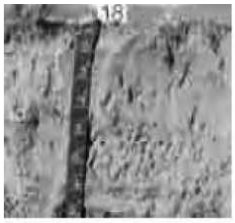
The current watershed approach which was very well conceived, now needs to be expanded to include overall Riverbasin Management to ensure that every drop of water which is received is usable and is used for improving productivity & multiplying crop production.

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



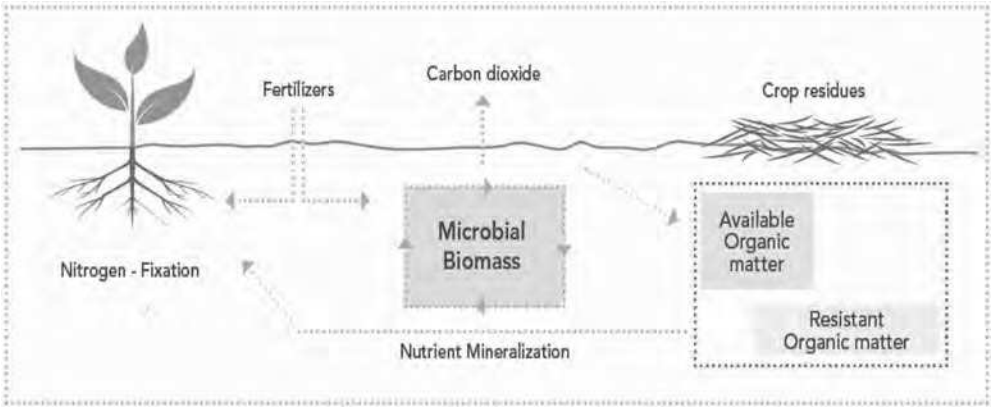



Life support services	Provision services	Regulating services	Cultural services
• The soil renews, retains, and delivers plant nutrients and provides physical support to plants. • It sustains biological activity, diversity and productivity.	• Soil is the basis for the provision of food, fibre, fuel and 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 (comminution) 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 4.3). 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

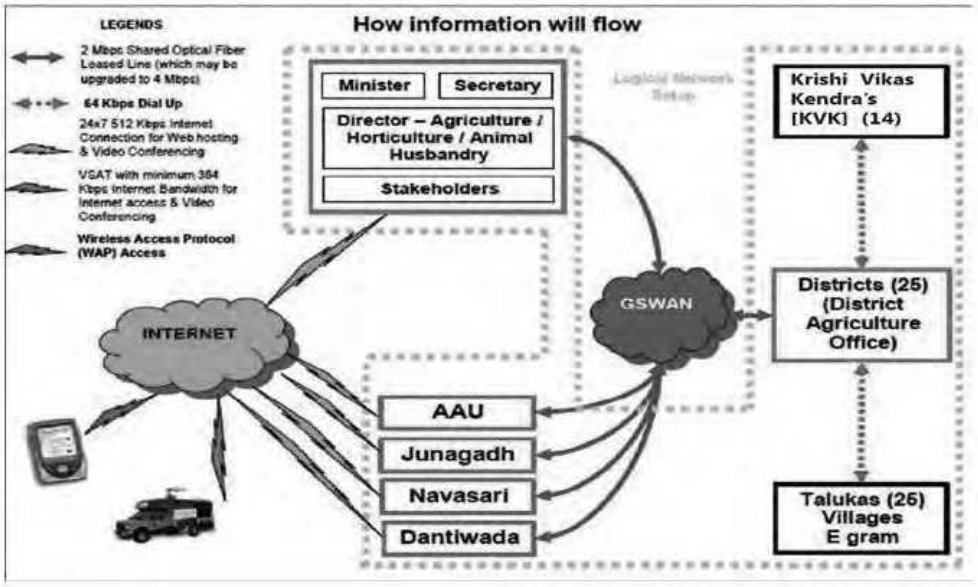
It is now increasingly realized that the impact of climate change is on Mother Earth the land or its content - the soil.

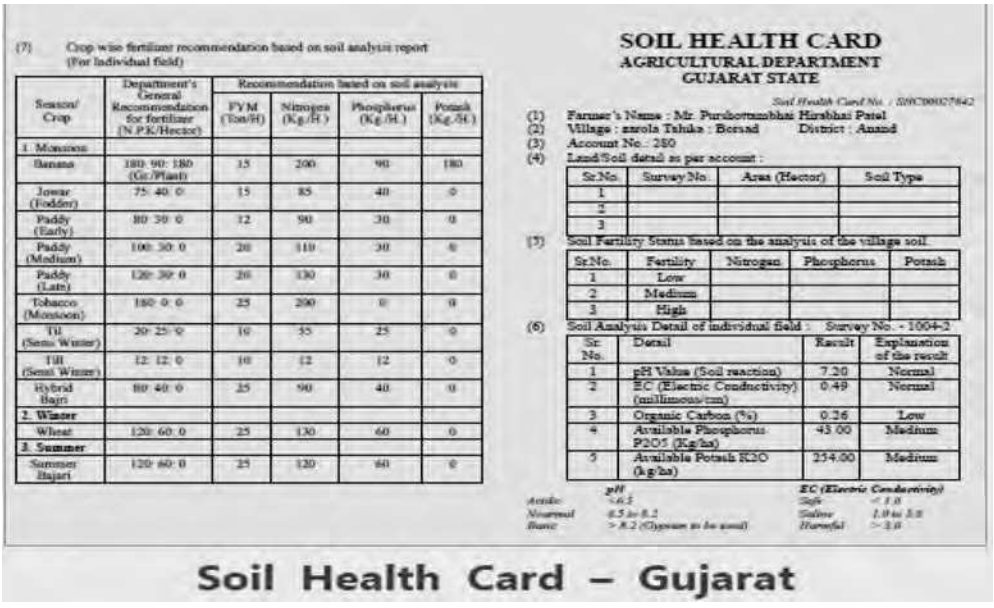
- The increase in temperature is absorbed by soil
- Lack of rainfall or less rainfall reduces its moisture content
- Heavy rain or floods impair its upper crust

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 fertiliser recommendation based on soil analysis report (For Individual field)

Season/ Crop	Department's General Recommendation for fertiliser (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	35	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. : GJOCD00275842

(1) Farmer's Name : Mr. Purshottambhai Hirabhai Patel
(2) Village : anrola Tahuka : 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 H2O (kg/ha)	254.00	Medium

pH		EC (Electric Conductivity)	
Acidic	<6.5	Safe	< 1.0
Neutral	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 land 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 plugging 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 onfarm 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

OUR OWN EFFORTS OF CLIMATE SMART AGRICULTURE

In following pages Success Stories by farmers, government, civil society members and scientists have been narrated to illustrate that India has already experience to meet these adverse circumstances and it is important document for them, and make available to all farmers of our country for replication.

The Kutch Story

In the 19th century, a devastating earthquake struck Kutch on June 16, 1819. Before the earthquake, Sindhu River flowed in the region. Kutch was a green land which produced paddy. Agriculture and livestock flourished.

After the earthquake, the Sindhu River changed its course and disappeared from Kutch. The earthquake caused a nine-meter vertical displacement, which came to be known as the Allah Bund. Sea water made huge ingress into the land through this displacement, converting the entire area into a huge saline desert which came to be known as the little and great Rann of Kutch. The vegetation cover was slowly lost with high occurrence of famines.

Crops failed, drinking and irrigation water became scarce, health and sanitation was affected. Survival became difficult in this arid land. Farmers left agriculture and land soon became fallow. This resulted in large-scale human and cattle migration over the years, a trend which continued in the last century. In fact happened here is what we visualize this will happen in many parts of the world due to climate change. But the situation was changed in Kutch with persistent efforts by the people who were determined to make the desert green again.

The Shroff Initiatives

Shri Kantisen Shroff came to his motherland Kutch in the early seventies from Mumbai. He was the Chairman of the agrochemical firm Excel Industries Ltd in Mumbai. He has been now staying at Bhujodi – Kutch since last two

decades with his wife Chandaben. They are popularly known as Pujya Kaka and Pujya Kaki.

The Shroffs were the first to work for rural development in Kutch as a voluntary group. When Shroff started visiting Kutch, the region was facing recurrent droughts that led to scarcity of water and huge cattle and human migration. The Government was running a few relief projects to provide livelihood and create community assets such as ponds, roads etc. The villagers remained occupied in such projects whenever monsoon failed – from September till the beginning of monsoon next year. The most severe droughts occurred between 1968-70 and 1973-75. This was when Shroff thought of a solution to the problem on a long term basis.

Shroff set up a number of voluntary organizations to involve people in sustainable development projects. These included the Vivekananda Research Training Institute (VRTI) at Mandvi in Kutch, Shrujan – Bhujodi-Bhuj and Shroff Foundation Trust in Vadodara.

Shrujan was developed by Chandaben for promoting assured livelihood and self-respect amount rural women of Kutch, who were highly skilled in traditional embroidery work.

Pujya Kaka developed a participative approach which involved people as well as Government agencies. This, in turn, created a local committee of participants who implemented the programmes. All these were done with convergences of efforts and active involvement of Government agencies and by taking up development programmes initiated under different government schemes.

A clinical approach was taken, which involved the diagnosis of a problem, a prescription for its solution and its implementation. The programmes were planned taking into consideration the local requirement and involved the use of modern technology. Some of the success story replicating above of Mundra, Lakhpat and Mandvi block of Kutch district are as follows.

Salinity Reduced By The "Trench" System

Dhrub village, Mundra – Kutch

Dhrub village, situated east of Zarpara village, witnessed large-scale migration of Turks in ancient times. Along with the Turkish community, came dates from the Middle East. As time passed, the community started sowing date palm seeds in Dhrub – a land with soil, water and climate perfect for growing dates.

The success story of date cultivation in Dhrub spread to nearby villages and soon date palms covered the entire Mundra Taluka,

Ground water was the major source of irrigation. Earlier, water was drawn by using leather bags. The seventies saw the use of oil engines and electric motors. As a result of proper irrigation, farming progressed. But this success lured farmers to dig deeper and draw more and more ground water. This, unfortunately, was the beginning of a vicious cycle. The greed to have "more" water brought down the level of ground water. Saline water ingresses in these areas increased the salt content in ground water. The water was then unfit for irrigation purpose. Farm produce drastically declined. People then realized that it was a grave mistake to use water without discretion. Their greed to exploit resources had cost them dearly.

Around 10,000 chickoo trees and 3,000 date trees used to cover almost 90 per cent of this farm land, in addition to guava, jujube and bijora trees. Crops such a lucerne, jowar, carrot and cotton were also sown in the past. But over exploitation of ground water had left these as only memories of the past.

Trench System:

Shroff and Mavjibhai of VRTI talked to the Sarpanch and villagers about the water scarcity problem. They suggested a trench system to solve the problem. Under the system, a one-and-a-half foot trench is built, which encircles the trees under irrigation. It is filled with biomass, which helps in the growth of its root. The approximate expenditure for building a trench is as follows:

Expenditure for trench around 1.1/2 feet around tree Rs.30/-

Expenditure for filling farm waste Rs.15/-

Expenditure for 7 to 10 kg organic fertilizer Rs. 30/-

Total expenditure on a trench Rs.75/-

Expenditure on sowing 40 trees (per acre) Rs.3000/-

Around 40 trees can be cultivated in each acre and the expenditure is around Rs.3000.

Approximately 1000-1100 liters is saved in irrigation. Trees can now bear fruits with less water and give permanent income to farmers.

If we talk about the water-basin in this area, then,

- One bed for chickoo is 5 m x 6 m (l x b)

- 4 to 5 inches of water to be filled, thus one bed will utilize 3000 to 3,600 litres of water
- It can be irrigated twice in a month
- Water to be filled in a trench around the tree
- First round of 2 meters around three (2 x 3.14 x 2) 12.56 square meter
- Second round (2 x 3.14 x 1.55) 9.73 square meter

More water is supplied in the trench system, but the total quantity of water used is however less than that utilized in the furrow system. Villagers adopted the suggestion and followed the instructions of volunteers of VRTI who visited these areas regularly.

The work started in 2004. At present, there are 45,000 fruit giving trees in this village. The average annual income of the participating farmer is Rs.12,000.

Jakhani village – Mandvi-Kutch

Saving water and soil nutrition by making changes in the system of growing dates

Dates are known in Gujarat as "the Kalpvruksh of Kutch" (Kalpvruksh is a mythological and an imaginary tree satisfying every desire). Usually, dates are cultivated on the sea strip in the areas of Anjar, Mundra, Mandvi and Abdasa. Among these places, the major area covered by date trees is in Anjar and Mundra Talukas. Even today, dates from Dhrub village are popular all over India. As discussed in the preceeding section the credit for bringing dates to Kutch goes to the Muslims of Dhrub. They migrated years ago from Turkey and brought along with them dates which was regular part of their diet , they began sowing the seeds. Even today, eating dates is customary in Kutch. While traveling by bullock carts, people in Kutch consume dates for snacks.

Gradually, dates became an important crop. People started growing dates on the border of their farms. A distance of one or two meters between two trees was maintained. The male and female trees are separated and the process of pollination is done by hand. Secondly, only after inflorescence can it be decided whether the tree is a male of female. But all the trees do not give uniform fruits. However, the farmers do not uproot trees even when they bear poor quality of fruits, as they have leased the entire orchard on a contract basis. The lease is based on the number of trees in an area. Contractors are concerned with the quantity of the dates rather than quality. As a result, their orchard started yielding poor quality fruits. The matter came up for discussion

when Pujya Kaka – Shri Kantisen Shroff came on a visit.

- The solution was removal of trees of inferior quality. Vivekanand Research and Training Institute agreed to help bring about changes in the system of growing dates and raise farmers' income

They selected 'Kinuwadi' for giving guidance to the farmers and brought an Israeli expert for developing a model farm. Every year, the Israeli expert came here during the date season and educated the farmers in growing dates in a scientific manner. The farmers also sowed new culture based date plants. The farmers in the areas around Bhujpur, Zarpara, Dhrub and Samaghogha started experiments based on 'Israel Technology'.

The Institute resolved to grow more than one tree of the same features using Tissue Culture; remove the trunk of bad dates and to bury it deep under the soil so that it became a fertilizer. They would also terminate the contract system of selling dates. Farmers were encouraged to sell dates themselves. By doing this, they would know about good quality dates and market needs too. More income would be available by removal of middlemen. They urged farmers to clean dates, remove bad dates and old fruits and to undertake systematic farming, use fertilizers according to the age of the trees in the months of November-December and ensure better quality dates by growing male flowers. Based on the ability and strength that each tree could sustain the bunches of dates were maintained and the exceeding bunches were eliminated to maintain quality.

- Inferior quality dates would be used as fodder for animals.
- Obtain good organic fertilizer by drying date-leaves. The leaves could be mixed in the trunk of the trees, with a residue of fodder eaten by animals. The farmers would also observe the growth of good dates and record their history to help in growing similar trees
- Steps should be taken to prevent infestation and disorders brought about by fungus, harvest date crops on time and arrange to pack and sell on time

Results

- Farmers started the process of selling and packing dates according to market needs
- Dates came to be regarded as an important crop. Sowing was made by keeping a distance of 8.8 meters of 7 x 7 meters between plants

- Farmers started removing trees of inferior quality
- Production went up and reasonable profits were available as quality of dates improved.
- Average income increased as bad dates were removed and
- Underground water was now judiciously used, and nutritive elements were made available.

It would not be a surprise if in the near future, dates become "Kalpvruksh' not only for Kutch but also for Gujarat!. Modern technology was obtained and adopted and the benefits were explained to farmers. In modern days, this is known as Knowledge Economy using successful technology from one who has it by providing to another who needs it.

Abdasa & Lakhpat Taluka - Kutch

Fodder Bank : A boon in times of crisis

Abdasa and Lakhpat Talukas of Kutch are well-known for cattle-rearing. But people there are gradually bidding good-bye to this profession due to recurrent failure of rain and water scarcity because of which cattle rearing was difficult. During such times, relief work is undertaken and grass depots are set up by the Government to protect people as well as cattle. Despite the fact that almost Rs.100 crore is spent on these measures, the situation remains the same when rains fail.

A 'Drought Prone Area Development Programme' was launched by Rural Development Department (Government of India) operated by District Rural Development Agency at local level. Its purpose was to organize people along with work and resources needed to prevent droughts.

The Programme was to preview water problems of the villages, see to it that enough grain is available from farming and that fodder for animals is made available in the village itself and employment for locals is also created. The programme was undertaken in villages of Abdasa and Lakhpat talukas. The impact was visible. The community was involved, there were inter-action at village level with experts of different disciplines.

Progress was visible. Local discussions with experts were encouraged and the following action steps were set

- Uncultivated land in the village was to be improved
- Better quality grass-seeds had to be sown

- Jowar seeds should be sown on uncultivated land and even as a regular crop and
- More fodder should be grown and stored when the times are good. Some of the guiding principles were that if the village water storage remains in the village, then the problem of water deficiency can get solved. Similarly, if the village fodder remains in the village, availability of fodder will not be a constraint. On the basis of this, it was decided to have a Fodder Bank in three villages by VRTI (Nalia)

To structure regular availibity of fodder associations for animal husbandry were formed in Ashapar, Sudahdro Moti and Sudahdro Nani. Every cattle owner became a member by paying a membership fee and by contributing two to three measures of fodder. The association opened a separate bank account. A revolving fund was set up.

The year 2003 saw good rains and plenty of fodder. The committee procured and stored 64,280,41,000 and 88,080 kilograms of jowar in Sudahdro Moti and Sudahdro Nani respectively. Insurance was also taken against any loss due to accidental fire. The following year, rainfall was scare resulting in an acute shortage of fodder. But, for once, villagers had no worries, as enough was in store.

Earlier in the absence of a Fodder-Bank, villagers were solely dependent on fodder from Bulsar village. The villagers from these three villages now can procure better quality fodder at a reasonable price and without being dependent on external source. Thus, the fodder bank proved to be a boon in times of crisis. This reinforced that any crisis can be resolved with commitment and joint efforts. from the local community i.e.the villagers themselves by bringing them together, identifying common interest and by proving a way for joint efforts.

Zapara village – Mandvi-Kutch

Praiseworthy Attempt to re-establish farming

The land of Mundra Taluka situated in the southern part of Kutch district is made up sedimentary rocks as it had been comparatively more recent emergence from the sea is the last one to emerge from the sea.

In the distant past, a lot of water was present in the layers of sand. In the past, Maldharis used to dig deep wells (5 to 10 feet) and draw water with the help of bullocks. Crops of cotton, sugarcane, nuts, vegetables and bananas were cultivated, as the layers were fertile and water was of good quality. But as time passed, Kutch was affected by recurrent droughts. With modern technology, farmers started pumping underground water – the result was depletion of water level and salinity ingress. The TDS content in water increased from 2500 to 3000.

Shri Kantisen Shroff reverently known as Pujya Kaka, during his visit to villages, noticed that the problem could be solved by controlling salinity. The 'Salinity-ingress project' was started in the monsoon of 2003, with the financial help of Sir Ratan Tata Trust and Shree Vivekanand Research and Training Institute and the help of farmers. A detailed micro-level plan was prepared.

- A check dam to be built in a rivulet at the cost of Rs.7 lakh
- Take water to the lake through the canal
- A local committee was formed. Villagers were encouraged to join the effort and the project started.
- The committee of farmers was registered. It supervised the work
- The local committee was assigned the task of maintenance of the structures, the distribution of water and its judicious use.

- The work was finished before the monsoon of 2004. The rainfall recorded was 400 mm

Results

- Beneficiary farmers' families - 17
- Total accumulated water - 1,03,792 cubic meter
- Benefited areas - 47,48 acres
- Crops sown : cotton, pearl millet, wheat, lucerne, carrot
- Produce/production from 47.48 acres: - Cotton (8.66 acres)
  - 8,992 kg
- - Pearl millet (8.63 acres) - 13,780 kg
- - Wheat (2.19 acres) - 32,380 kg
- - Jowar (fodder 8.00 acres) - 13,800 kg
- - Lucerne (fodder) (20.00 acres) - 1,500 kg

Kemtharpur village – Mundra – Kutch

Saline Area, Saline Water, Drip System

Mundra Taluka: Salinity here has increased due to proximity to sea. Farming is no more remunerative. Efforts are on to prevent this salinity. The Vivekanand Research and Training Institute accepted the challenge. The objectives were,

- Prevent salinity due to sea water ingress
- Develop farming in this area and
- Make arrangements for water access for irrigation

Experiments 'to improve upon the salinity" and 'drip irrigation system' were undertaken. Dates, mangoes, guava and sapota were cultivated. The organization explained the benefits of accepting the "Drip System' to the farmers. Farmers were worried that the 'Drip System" would not be enough and trees would dry up in the course of time.

It was then decided to take the farmers on visits to places where these experiments were being carried out. Farmers were taken to the farm of Shri Vikram Sinh Jadeja, a leading and progressive farmer of Khedoi village in Anjar Taluka, where the 'Drip System' was used for guavas (on 10 acres) and mangoes (on 5 acres) of land. Farmers presented their problems and got satisfactory replies. Their faith was revived in the Drip Irrigation System. Ten farmers from Dhrub, where there is estimated 5,000 to 5,500 TDS water, fixed the 'Drip Irrigation System'. A small beginning was made in the new date plantation – land was not very hard and small date plantations required less water.

Such a system was also installed in a farmers' orchard in Kemtharpur, where the land is full of Sapota trees and many of them aged beyond 20 years. The farmers did not have faith in the beginning, but they also agreed to adopt the system. They were provided detailed guidelines on installing and using the Drip System. Gradually, moisture gathered in the land because of organic manure and bio-mass. Today the farmer is more than satisfied. Their trees are stronger, productive, attractive and water is saved.

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 favorable market mechanism that rewards conservation initiatives. This is called the 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

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





Hypothesis – Water: Community's access to weather monitoring and prediction data combined with community managed water resource systems can lead to greater water use efficiency and improve adaptive capacities.

Activity	Output	Outcome
Lining of Harren, awareness & capacity building	• Year – 2007 • 780m lined channel (Harren) constructed • 24acre area brought under irrigation • 41 farmers irrigated wheat crops, 6 times / crop	• Group of farmers evolved norms for efficient water use
	Output Indicator	**Outcome Indicator**
	• Length of water channel lined • Area brought under irrigation and No. of irrigation provided	• Ability to manage the irrigation channel by functional group • Increase in water productivity • Time saved for irrigation
Benchmark	**During 2006, 0 m lining, 39 farmers irrigated wheat crop in 20 acre area by using 6 irrigation**	**Rainfall** **2006 – 1158mm** **2007 – 566mm** **2008 – 672mm**

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

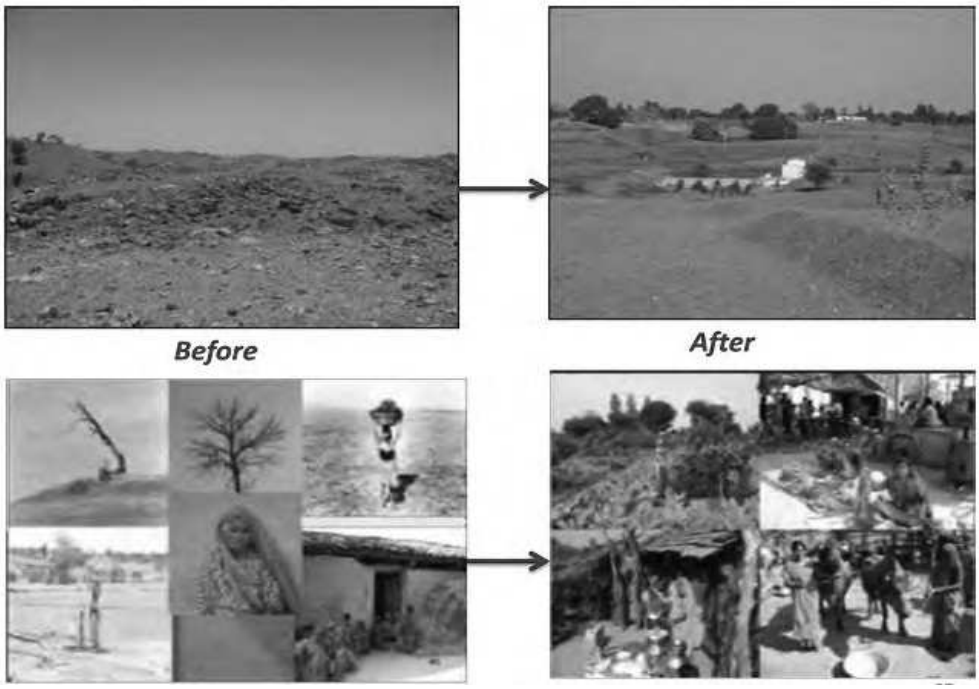
After restoration of Mangroves - 2004

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

TRANSFORMATION OF DAHOD – GUJARAT

Dahod is a remote tribal district in Gujarat, India with a most difficult terrain. Prior to 1974, it was the poorest district in the country and drought prone.

- The tribal villagers migrated every year after monsoon
- The irrigation coverage was just about 5% in reality compared to 10 % on records.
- Agriculture yields were poorest with predominance of maize crop and milk production lowest despite high cattle population.



- Literacy rate was very low.
- The undulating terrain was barren land with hardly any tree cover, no forests in the designated lands or any other form of cultivation.
- Most of its forest land is without tree cover
- No horticulture, vegetable or floriculture

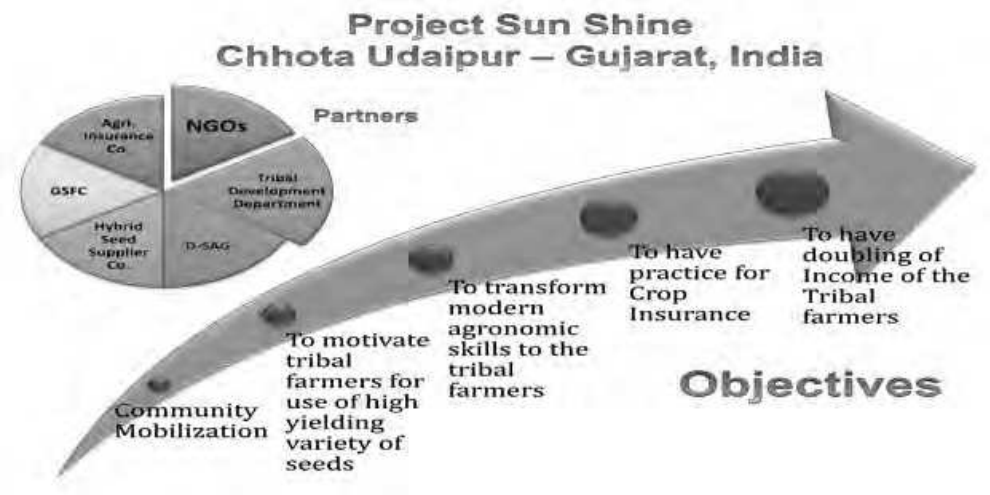
In 2010

- The same desolate area achieved food security, the housing conditions improved
- School enrolment and attendance increased manifolds
- 68,000 ha of land were brought under irrigation. 17000 wells re-charged and the irrigation coverage rose to around 30 %
- 700 community water resources developed & were managed by 325 village level irrigation co-operative societies.
- 2,700 village institutions - users groups managed their affairs & assets - 65 rivers and rivulets were made perennial through series of structures connected to lift irrigation system and the migration dropped to 10-15 %.
- Cropping pattern changed with introduction of horticulture - mangoes, floriculture, roses and vegetable crops. six crore trees planted with 50 % survival at long run
- About 25,000 farmers opted for horticulture with average income of Rs.50,000/- with continuous increase in income of poor families also.

The approach by NGO – Sadguru Foundation led by Harnath and Sharmistha Jagavat was convergences of efforts and channelizing programme of government departments and organization, banks and creating / motivation local leadership – building of local level institution of farmers with participating management and providing market link based on demand survey.

THE USE OF TECHNOLOGY FOR CLIMATE SMART AGRICULTURE

Chhota Udaipur – A remote tribal district in Gujarat, India



Source: Shroff Foundation Trust, Vadodara, Gujarat, India

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

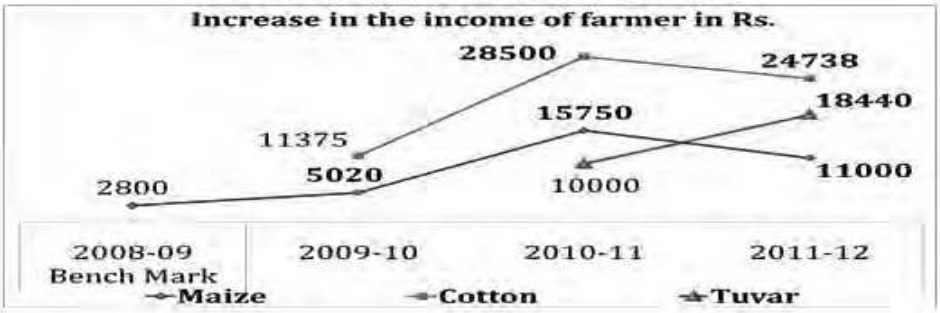
Cotton Crop

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

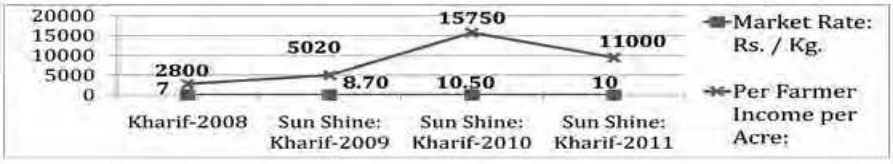
Year wise Coverage		2011-12
Blocks		Chhotaudepur & Jetpur Pavi
No. of Villages		352
Allotted Targets		3500
No. of Farmers Benefited		3500
Collected Community Contribution		Rs. 52.5 lacks
Seeds Distributed		3.15 MT
Fertilizer Distributed	DAP	175 MT

Crop wise increase in the income of farmers



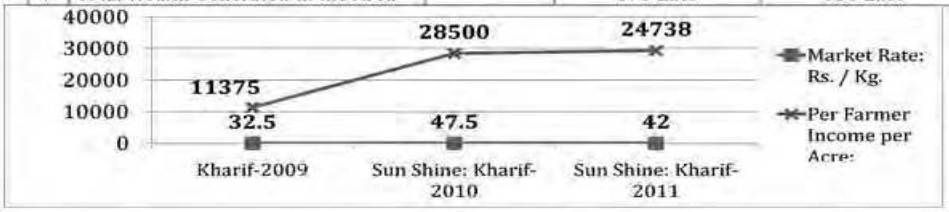
MAIZE Crop – Yield details

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: Maiz-8 kg.- 2 begs, D.A.P-50 kg.-1 beg, Yuria-50 kg.- 1 beg, Pottash- 50 kg.- 1 beg
- 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: Maiz-8 kg.- 2 begs, D.A.P-50 kg.-1 beg, Yuria-50 kg.-1 beg, Pottash- 50 kg.- 1 beg
- 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 begs, D.A.P-50 kg.-1 beg,

Yuria-150 kg.-3 begs, Pottash- 50 kg.- 1 beg, 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 begs, D.A.P-50 kg.-1 beg, Yuria-150 kg.-3 begs, Pottash- 50 kg.- 1 beg, 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 beg, Yuria-650 kgs.-13 begs, Pottash-900 kgs.- 18 beg, 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

Energy-smart food objectives		CSA objectives		
		Sustainable increases in productivity and income	**Strengthened resilience to climate change and variability**	**Agriculture's reduced impact on climate change**
	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!!!

Drip irrigation system

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)

ADAPTATION MEASURES

❖ **Crop Diversification**

Cropping system	Total variable cost (Rs/ ha/yr)	Net returns (Rs/ha/ yr)	WUE (Kg/ m^3)	Electric consump-tion
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)
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)		

Raised bed planting in wheat

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**

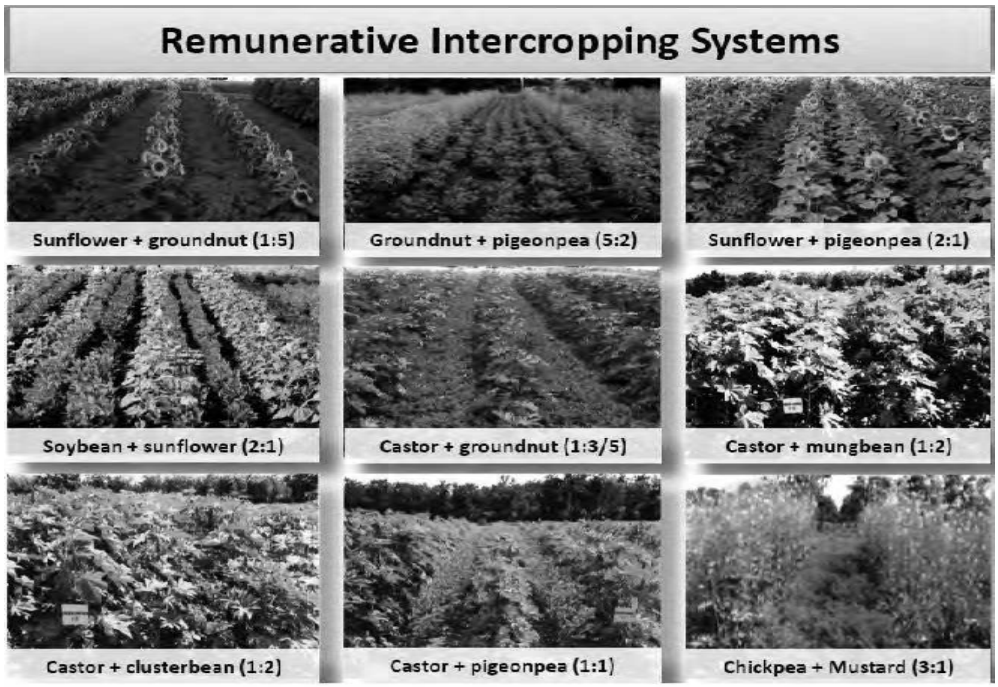
Saturation of whole villages of Ganakdoloni near Biswanath Chariali in Assam

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 hardy crop

In Gujarat Castor which was sparing grown in early fifties has transformed economy of North Gujarat which is a drought prone area. Castor plants is late sowing, needs little water has minimum pest problem. It is also salinity and heat resistant.

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 forwater 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, ChhotaUdaipuir.

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 buffalos 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 temp erature 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 PRODUCTOIN:

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 temp erature 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.

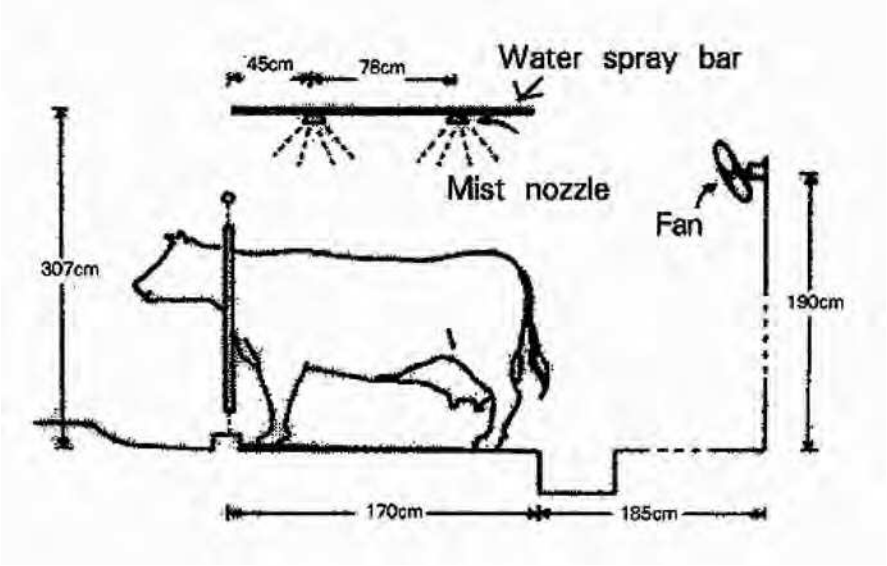
1) SELECTION OF MILK ANIMAL BREED:

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 requirementof 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 parlor 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 jowar (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 dieses 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

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 dames due to floods	• Repair check dames. • 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. Washing out of soil strata and spread of salinity due to cyclone both underground and over-ground.	• Farmers have to be given alternative land • If feasible protection wall has to be constructed along with plantation of mangroves outside of the wall • 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

THE SUPPORT ACTIVITIES

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

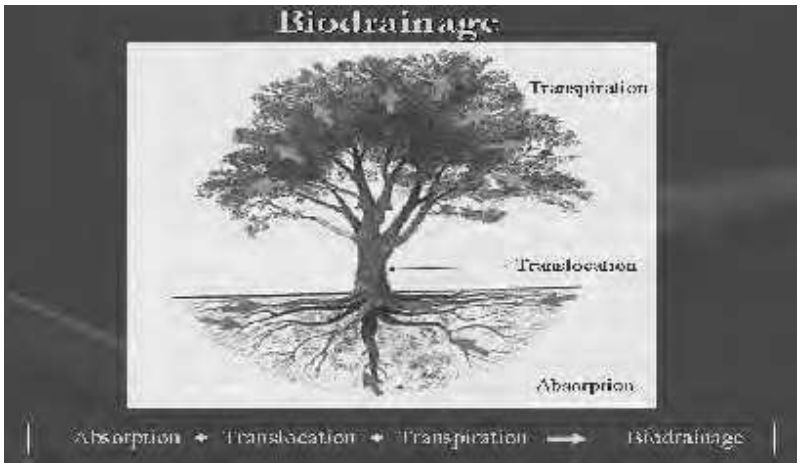
Source : Dr. J.C. Dagar, Formerly ADG (ICAR)

❖ **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.

Case Studies

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

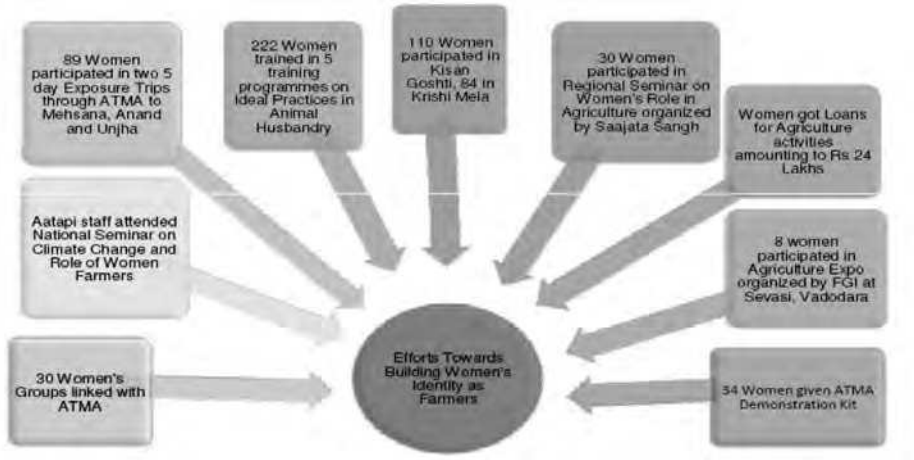
Women play important roles in agriculture production. These roles pertain to all aspects of crop production / protection, management of livestock, farm animals / husbandry and fisheries but are treated as “workers” and not farmers.

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 responsibilitiesin 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 lessions 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 12th 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 leukemia 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.

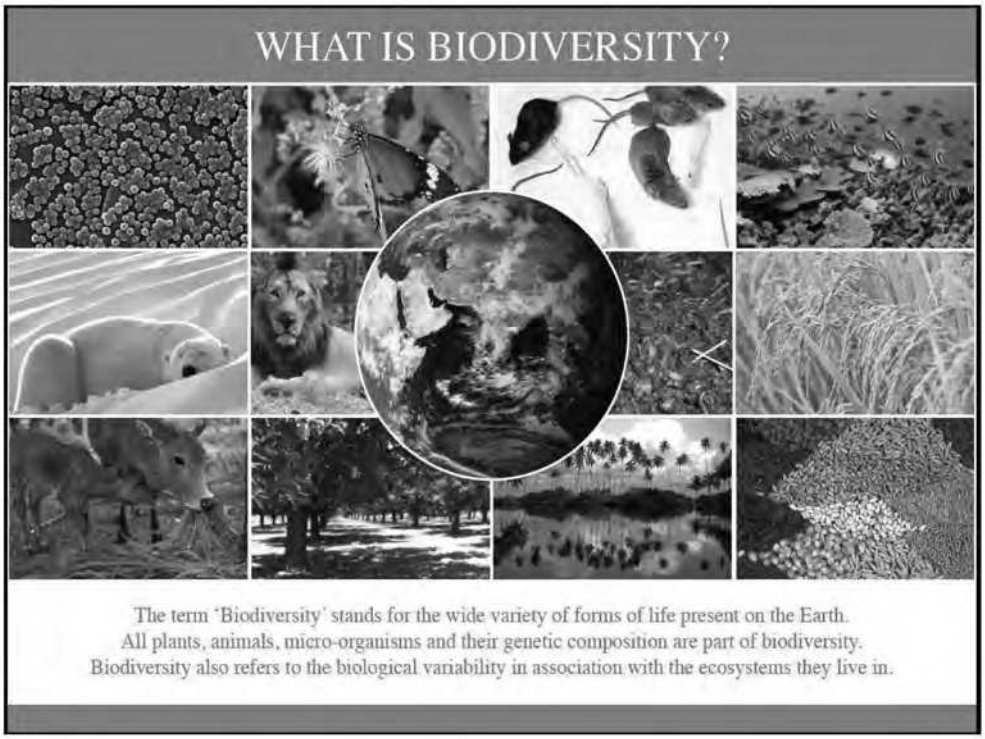
Nagali Value Addition:

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



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 dieses 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

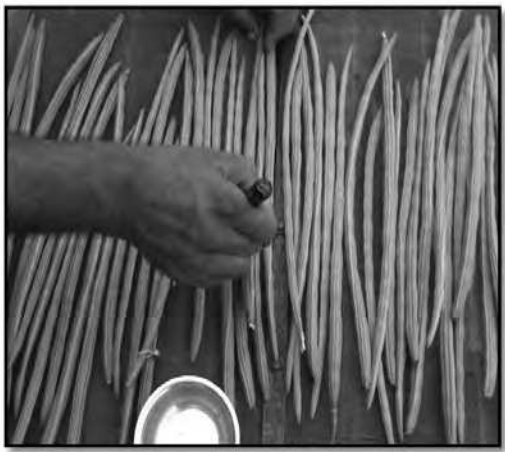
Photo two photos from presentation

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.

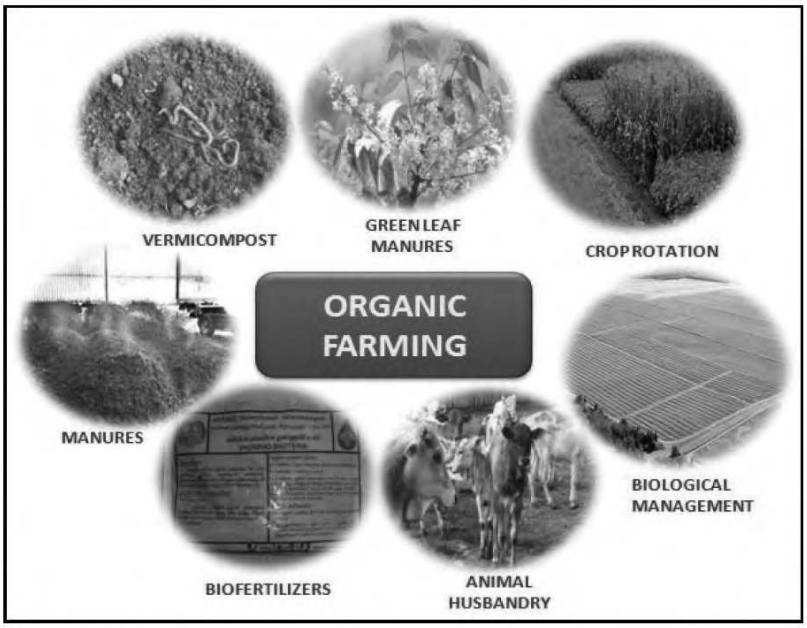
ORGANIC FARMING

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 residuem 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 crp. 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.

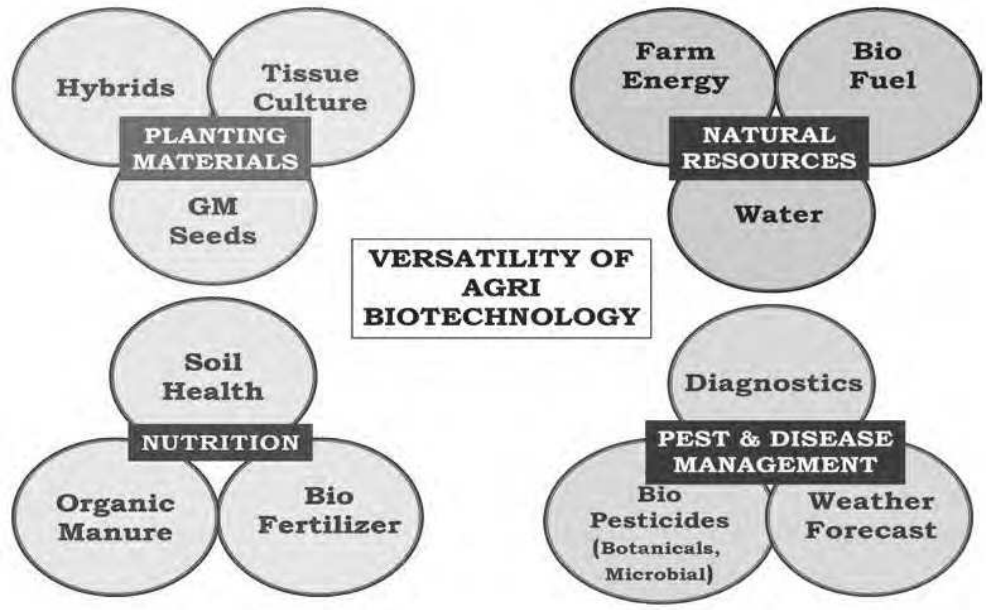
It has a key role to solve development issue and to provide (a) rapid development (b) provide sustainable livelihood to small farmers (c) meet challenge of food security (d) provide food at reasonable price to hungry millions.

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

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 continuosly monitered.



WEATHER FORECASTING

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 un-foreseen weather changes for example like:

Increase in heat – temperature	Provide irrigation
High wind velocity	No spraying of pesticides
Un-seasonal 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.

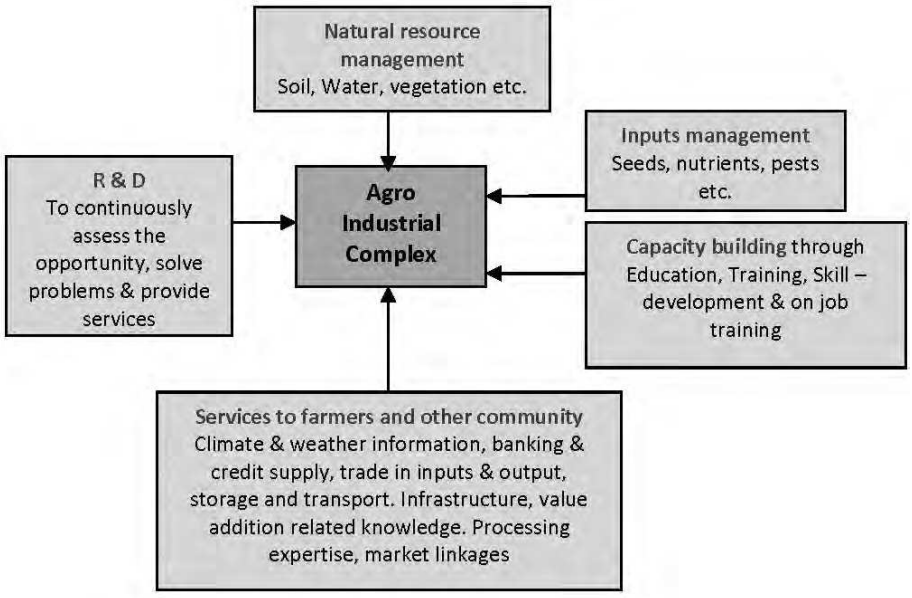
Another major adverse impact on rural youth is easy influence by groups which encourage internal violence, spread of terrorism and missapropriate others income through extortion . In India, this is prevalent in some districts and is known as “Naxalism”. Since the rural youth are susceptible to these 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 carrer 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 inspite 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.

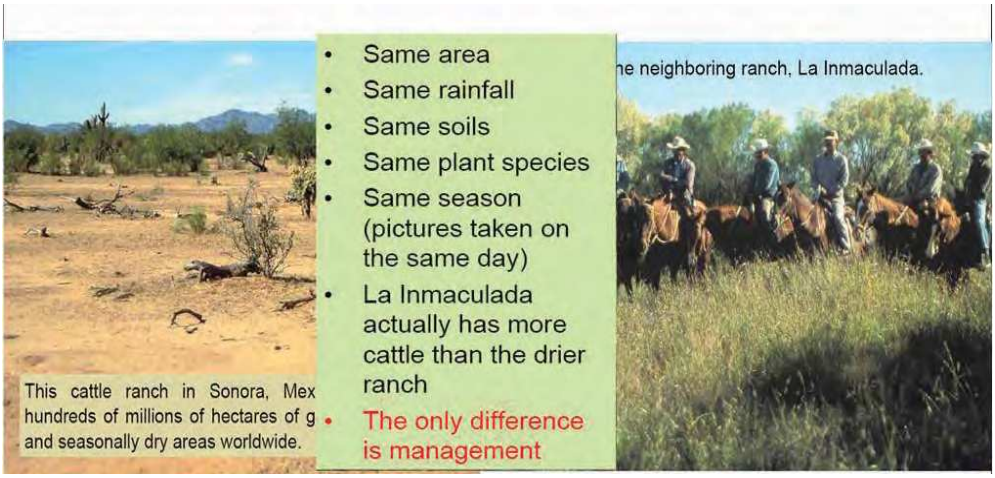
Due to lack of proper management and improvement, productivity of grasslands is very low. For their proper management and improvement focus should be on following points:

- 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 and encourage. 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 clock 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. 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			

Yoeld 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 *kharif*	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 to 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 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.

THE KNOWELDGE ECONOMY

Application of knowledge is the key to bring about rapid growth and to usher in sustainable development, says Prof. Mukul Asher, Professor of Public Policy, National University of Singapore. The term Knowledge Economy (KE) reflects the importance of knowledge for development process. It involves countries, organizations and people to acquire, create, disseminate and use knowledge more effectively for greater economic and social development. It includes application of successful technology of one field to another field. It provides more efficient ways of producing goods and services and delivering them more effectively and at lower costs to a greater number of people. It includes developing a market mechanism strategy for remote – rural areas – within a country and merging it into global market.

It requires transfer of Knowledge Economy from Advanced Countries who are generating most of this knowledge to developing countries, which need it because of their limited awareness, poor economic condition and weak institutions and within developing countries from its manufacturing sector to agriculture sector. Knowledge revolution has a major role to play in the meeting challenge of global warming and development of agriculture and through that sustainable development.

Indian Space Research Organization (ISRO) played an important role in using knowledge developed for betterment of the rural economy. Under the guidance of Prof. Yash Pal, ISRO introduced development communication, distant learning, micro-level planning, watershed, crop forecasting, etc. for the benefit of farmers.

Application of Knowledge Economy Tools in Agriculture Includes:

- Provision of information to the farmer about farm prices by use of ICT mobile phone, TV & Radio news bulletins & web-based technologies.

- Specific product feature choice and requirements of the market (example of straight chilies, reddish tomatoes being more preferred than their ordinary counterparts so that farmers can plan accordingly to secure high prices
- Introduction of village level micro irrigation plans for contour banding, gully plugging, check dams and village ponds and farm ponds based data from satellite imagery.
- Development and use of cheap mass produced sensor technology that can detect spoilage in food stored particularly perishable food.
- Mapping increase in salinity, affected and eroded land, wasteland and wetlands and agricultural land reduced due to urbanization.
- Aerial seeding in margin areas of descent and coastal areas.
- Developing marketing modules. If we can supply tooth paste and match boxes or cigarette at same price in all over the country, why not vegetables? Why onion are sold in Maharashtra and Gujarat at Rs.10/- and in Delhi Rs.50/-? Why only price come down after agri season is over? Expertise of industrial products supply chain - storage, delivery need to be replicated.

CLIMATE JUSTICE

Justice means: 1) Fairness. 2) Moral rightness. 3) a scheme or system of law in which every person receives his/her/its due share from the system, including all rights, both natural and legal. The attorneys, judges, and legislatures and public administration systems often get caught up more in procedure than in achieving justice for all. Example: the adage "justice delayed is justice denied," applies to the burdensome procedures, lack of sufficient courts, clogging the system with meritless cases, and the use of the courts to settle matters which could be resolved by negotiation or by quick administrative decisions. The imbalance in the judicial system, where wealthy clients are able to influence attorneys vis a vis a poor farmer is the main reason for grievance and delayed justice.

Sustainable Livelihood means:

- To provide adequately for ones existence
- Cumulative increase inspite of natural adversities

Climate Change:

Climate change is the most difficult challenge in the new millennium, due to its un-predictability, increasing frequency and intensity of its impact on habitat particularly on livelihood. This gets magnified for rural areas where majority depend on agriculture as direct or indirect source of income:

- Climate Change has become most important threat to livelihood of farmers. It adversely affects entire sustainable development process.
- Impacts due to Climate Change are becoming increasingly evident especially through unpredictable weather, monsoon and productivity constraints. These in turn have a significant impact on farming with changes in the physical, chemical and biological profiles of soils, waters and biological parameters affects productivity fails crops or yields from livestock.

- The most tangible impacts are on the quality of life because of reduction in income and loss of productive assets.
- Devastating cyclone – Tsunami *Tornado* and floods affect entire habitat with destruction to houses, infrastructure level alongside farmers and livestock.
- Industry and urban township are mostly implicated in creating the externality through the release of pollutants and other emissions. They have to be made responsible for the challenges caused and sustain support to overcome challenges in the long term too.
- These are locally felt challenges of a global phenomenon and can be seen as externalities that the farmers are not responsible for. The stakeholders responsible for creating these challenges cannot be determined as there is no direct cause and effect relationship.
- But it is important to deliver justice to the affected communities in a timely manner. These should include technical, technological and financial inputs & safety net so that the farmers can tackle climate related challenges immediately and sustain such transitions in the future too or for that matter advisory on Climate Smart Practices.
- The larger questions pertaining to the aspects stated above have to be addressed through the climate justice perspective. The larger questions accordingly are:
    - What are the legal and administrative framework / provisions that the farmers can invoke so that their quality of life becomes the basis for redressal?
    - What can be the mechanism for ensuring responsibility from the industry and Urban Townships infrastructure projects like Ports Mining that generates these externalities?
    - What are the challenges to the existing rules and regulations and administrative practices which do not meet quick redressal and how they can be modified e.g.
- What existing safety net provisions and how they can reach out to individual affected families.
- What are existing Government Support Schemes which endeavour to meet these challenge as now they are most often get delayed in delivery at grassroot level

- What are existing Laws/Acts related to quality control etc.
- What inequities are faced by farmers viza a viz his urban counterpart
- What are measures to ensure that farmers receive in timely manner (a) warning focused on weather forecast for taking precautions measures (b) agro-advisory before and after event has taken place to sustain crops – livestock can this be made accountable?

For example

I. Crop Insurance	Average settlement period (1 to 2 years) While requirement is immediate for resowing	Car Insurance and Medical Insurance	Normally Insurance company makes direct payment- Cashless provisions
II. Inputs Seeds	No action if no germination takes place i.e. Seeds fails germinate any crop or less germination in relation to quantity of seeds	Consumable and non-consumable goods	Immediate exchange / replacement within stipulated period in case product fails to meet standards depicted
III. Sale of Agriculture produces	Gets banned for exports if there is internal (within country) shortage & price rise and farmers looses higher value from its sale if exports	Industrial products	There is no such ban

IV. Tenancy Law If farmers retains- hires a worker	Under certain conditions the workers can become owners – under Tenancy Act Farmers is under constant threat of local Talati who maintains land records.	Urban developer rents out house	But his Tenant can not become owner
V. Sale of Agriculture produce	Compulsory in local Agriculture Produce Market Yard where traders run action system and make cartel. This under APMC Act.	Sale of Industrial Produce	Industries can sell products wherever they want
VI. International assistance. Carbon Credit	Small farmer cannot fill up a form. Leave apart understand its complexities	This is devised only to help polluters with difficult format which can be filled only by Consultants	

VII. Organisation	There are organisations at national and international level which act as NGOs and voice farmers' interest. Some of them are promoted by private group/industries/trade organisation. Some of them mis-represent farmers' interest and even take up litigations to prevent adaptation of new technologies	Further, some of such organisations do not understand situation at ground level and represent farmers' representives in national and international meet. Farmers have actually no voice in what is being represented on their behalf.	

International/National perspective in measuring GHG emission.

Agriculture treated as net emitter due to use of fertilizer, cow dung etc.

But in reality agriculture vegetation is through photosynthesis process which absorbs Co_2 from atmosphere and releases Oxygen. While calculating net emission no set off is given for actual absorbs of Co2 by Agriculture.

Industry – Urban areas are net polluter as their activities enhance release of GHG

a) They are net emitter of GHG grasses some of which are hazardous

b) They displace agriculture land/ forestry land. Hence vegetation by non-agriculture use of land, prevents the absorption of Co_2 from atmosphere and release of Oxygen which is a natural process of vegetation/agriculture. This adds to total emission by Industries/ many urban areas.

Other related aspects:

The world is passing through unpredictable changes whether it is cyclone or heavy rain or drought or extraordinary snowfall. All these have already affected livelihood means of farmers who are at receiving end. This is main threat to food security and food for hungry millions. Strategies are needed how to overcome this challenge through strategic changes in developmental framework, policies and modern advanced technology with backup of a legal framework which provides redressal if existing programme and rule framework either fail or do not reach out to them within time limit prescribed. This only includes safety net provisions by way of insurance for crops, livestock, fisheries and community employment, timely weather forecast, agro-advisory and delivery of needed fresh supply of inputs to frames and feeds for livestock. It further envisages similar framework in case of total devastation due to Tsunami by way restoration. And enforcement of all these is required to be made in timely manner.

Climate justice is to view climate change as an ethical issue (causes and effects relate to concepts of social and environmental justice) linking equality, individual human rights and collective rights. This is also viewed from a historical responsibility. This creates the context for multiple legal and administrative systems to converge. These have increased by the events of suicide by farmers and precisely if, farmers' risks/opportunities are not covered in time, then nobody would do farming. Everybody would like to migrate to Urban centres or wed depend on Naxalism to obtain Justice through brutality. Naxalism occurs because Public Governance and Judicial System have failed to protect rights and provide ways to sustain livelihood of poors. The educated youth do not like this and they tend to take Law/System in their hand. This has already spread to 1/3 districts of India.

There is need by scholars, social media, NGOs, Governments, Farmers, and Organisations to give attention to following aspects:

I. Give voice to farmers, understand their options and empower them to act and promote Climate Smart Agriculture.

II. Suggest inclusive sustainable legal and administrative process with the involvement of all stakeholders to reduce inequality through appropriate redressal system and with protective assistance to get it.

III. Strengthen governance through local level public leadership for better accountability.

IV. Improvement in existing legal framework and tools to suggest ensuring preventive and remedial action to reduce vulnerability through transparent, credible, long – lasting and effective but quick enforcement of climate and related policies.

V. It will examine existing provisions, its limitations and suggest needed changes included in a new framework.

VI. Develop international perspective for UNFCCC- Climate related negotiations to focus on the need of farmers and give agriculture weightage as mitigation tool.

Indian Constitution has specific framework for social responsibility with focus on poor families under its Directive Principles. The government – both Central and States have come out with range of schemes, programmes for poor families of urban and rural areas. Some of very important programmes which are made statutory responsibility are Employment Guarantee Scheme and Food Security.

At international level all these is debated all the nations of world under UNFCCC climate conference of Parties – COP. At national level there is an overall positive atmosphere where all stakeholders, the Government, the Public Leadership, Civil Society, Judicial System, Public Administration even Corporate Houses are geared towards social responsibility and determined to remove poverty and inequity from our country. Hence, in near horizon we can look forward for positive outcome on all above issues.

CONCLUSION
THE WAY FORWARD

CONVERGENCE OF EFFORTS

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 small stakeholders and uneducated farmers, women farmers and rural youth.

Support: Information – knowledge

- About climate smart practices
- Financial support both credit and subsidy
- Market support

Co-ordinating all links in all above.

Approach: It needs changes in behaviour and strategies as well as changes in the usual timing of agri practices and adopting new crops / switch crops depending upon changes in weather pattern during season.

Needed Support:

I. Sharing technical knowledge

II. Providing credit, subsidy and safety net.

III. Monitoring and co-ordination of different agencies

Providing information to farmers :

- 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 is should be supported by agro - advisory

a) based on forecaste

b) after unforeseen climate event has taken place like heavy rains and flooding of fields.

- About opportunity to have multiple source of income

Different players in agriculture sector need completely different types of climate advise. The new extension mechanism has to keep this view.

- 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 ay post harvest stage – where they sell products or store it till the market price is improved.
- Farmer also need 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.
- Similiar advisory is needed for livestock management and fisheries.

Hence, entire exercise is multi- dimensional and extension officer have to be trained for that.

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 also increase their income level and in worst circumstances maintain it.

Source : adapted from CSA Source book, FAO 2013

NEW EXTENSION APPROACH

REACH OUT TO FARMERS AT DOORSTEP : 'KRISHI MAHOTSAV APPROACH' –

THE GUJART EXPERIECNCE OF SUSTAINABLE CLIMATE RESILIENT AGRICULTURAL DEVELOPMENT

Gujarat is a state situated on the western coast of India. Diverse in its topography, it boasts of a 1600 km coast line and is home to the largest desert in the country known as Rann of Kutch. The state has all possible handicaps faced by agriculture such as 70% of agriculture being rain-fed, recurrent droughts, untimely/irregular rainfall and some areas receiving rain only three to four days in a year. Gujarat's agriculture suffered heavily whenever there were droughts. The growth rate of agriculture used to be negative during such years. In a normal year, the agricultural growth rate used to be 2 to 3%. Agriculture was not sustainable in many parts of the state due to recurrent crop failures. However, this is a story of the last millennium.

In the new millennium, Gujarat, with determination and persistent efforts, changed the agriculture scenario. From 2004 onwards, agriculture witnessed a major turnaround with a growth of 11% per year. The state became a front-runner in agricultural production in the country. This turnaround became possible due to certain effective experiments and steps taken by people on the basis of the experiences mentioned earlier, Government's experience and that of agricultural universities. Such successful experiences did not remain specimen or model projects, but became a base to launch an overall initiative in all 18,000 villages in the state, known as "Krishi Mahotsav".

This was led by the Hon'ble Former Chief Minister Shri Narendra Modi – who is currently the Prime Minister of our country. This was led from top by Chief Minister himself - for action at bottom - the village level and at individual farmer level with focus on selection of crops which soil can sustain and free input assistance to poor farmers. He started first with direct dialogue with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ઓછે પાણી મબલખ પાક...

Climate Smart Agriculture - Kishi Mahotsav Approach















Climate Smart Agriculture - Kishi Mahotsav Approach





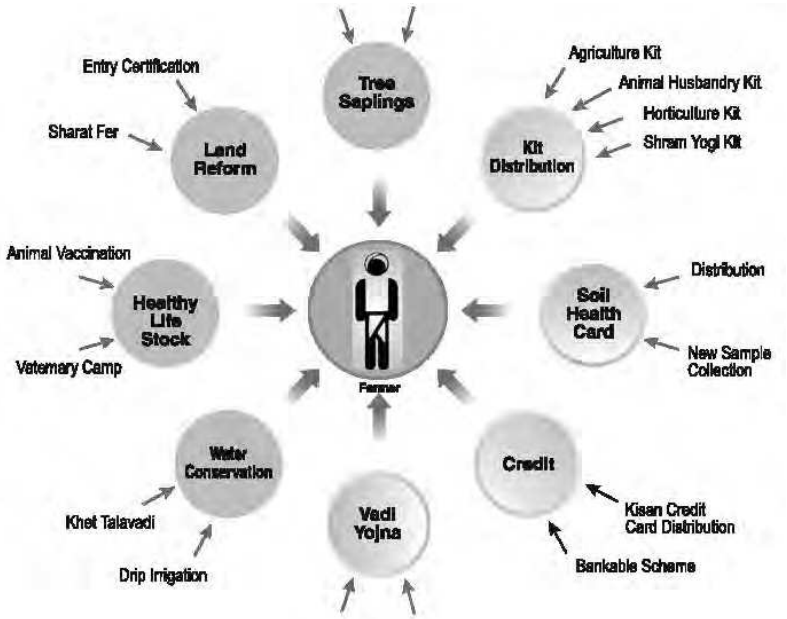


Climate Smart Agriculture - Kishi Mahotsav Approach

farmers and field functionaries followed by interaction with experts and departmental secretaries. Entire model developed based on needs of farmers and to provide knowledge and technology to them at door step. It is top to bottom approach.

The editor of book was responsible for developing policy and the detailed implementation framework and to develop module to monitor its implementation on day to day basis for period of one month prior to monsoon – when actual field level action is taking place.

New Extension Approach – Gujarat – 1



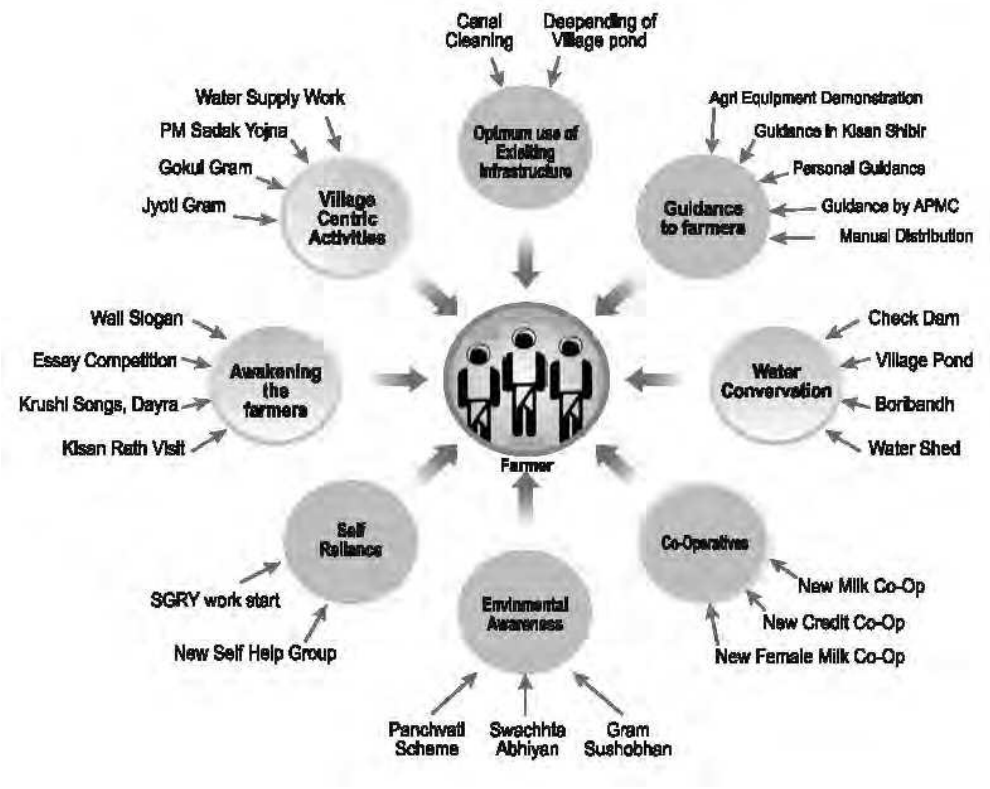
The key to this success was direct involvement of public leadership both elected and non-elected members of Public Governance System. Effective soil and water management and proper land use by using mass communication approach-based, micro level management model was introduced. On the water front, more than 1,00,000 check dams got constructed. In the last decade, the numbers of check dams were only 6000.

It inter-linked rivers such as the Mahi and the Sabarmati. These rivers, in turn, were linked with Narmada and Mahi canals. In its rain-starved areas, such as North Gujarat and Kutch, a special scheme for irrigation known as “Sujalam-Sufalam” was introduced.

Scientific agriculture was introduced by distributing Soil Health Card to every farmer. From 2004 onwards, 50 farmers from each village were given such cards every year including soil moisture analysis and past five year's average market price of the crop grown in their area. This helped them make informed choice in the selection of crops. Farmers now sowed crops that gave them higher return and were sustainable in the soil of their farms.

The poor farmers were focused for assistance. Every year 15 poor farmers of each village were assisted with free Input – consisting of Certified Seeds packaging Fertilizer and Pesticides and one tool like sprayer.

New Extension Approach – Gujarat – 2



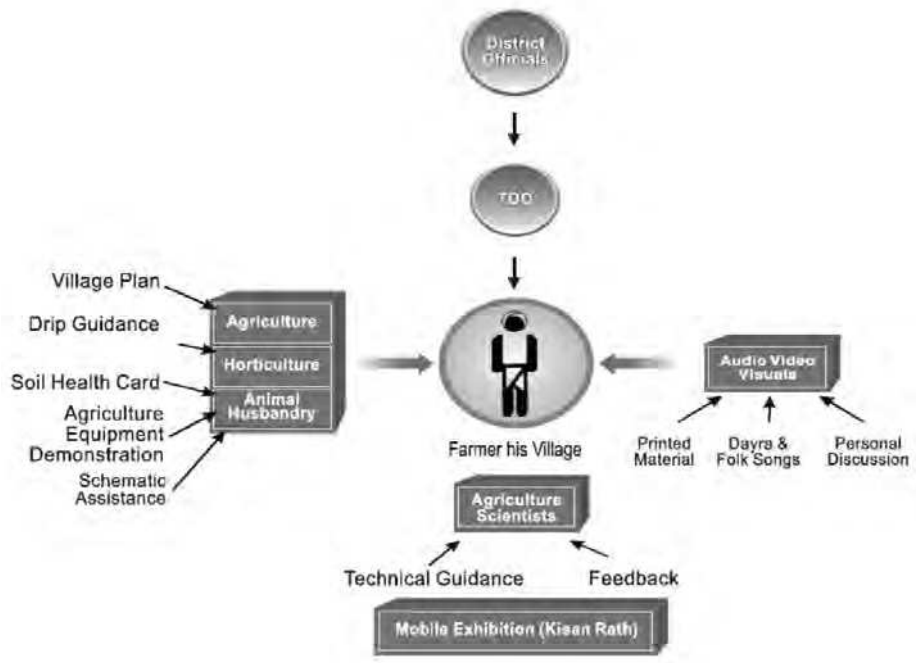
A direct door-to-door extension programme for guiding the farmers at village level was introduced under a pre-Kharif (pre-monsoon) programme, known as :Kirishi Mahotsav'. Every village was visited by a development team comprising agri-scientists and officers from the veterinary department, co-operative, irrigation department, rural development department and local

banks etc. High-yield crops were identified. The farmers were guided about using certified seeds and looking at price of APMCs before selling their farm produce. The campaign is by District Megistrate - DM and District Development Officer (DDO),

Bhaskaracharya Institute For Space Applications and Geo-Informatics, a institute set up in collaboration with Space Application Centre (SAC), Ahmedabad, by the Government of Gujarat, prepared a micro-level plan for land use by identifying sites for check dams and village ponds for every village.

Information and Communication Technology material was made available to the farmers in their mother tongue for crop management, including use of fertilizers and pesticides. Free telephonic help lines were introduced to answer the queries of farmers.

New Extension Approach – Gujarat – 3



All these initiatives were backed by total involvement of public leadership, both elected and non-elected. And all schemes related to farmers (narrated in chart) here converged at village level for implementation. The Chief Minister

to village Sarpanch, the Chief Secretary, to village level worker, voluntary agencies, input dealers and co-operatives and bankers – representing the rank and file of institutions were involved in the mass communication meets at village level.

The joint initiative brought about sustainability in Gujarat agriculture, bringing about overall growth in all important crops and an increase in the per capita income of the average farmer. The major transformation occurred in the state's most difficult areas of Saurashtra, Kutch and North Gujarat.

It is necessary that such experiences are replicated all over the country – in all its villages. The turnaround in Gujarat was due to effective public leadership.

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 annual growth rate in agriculture sector is about 3% while that of industry sector is 10 to 12% and of service sector is 30 to 35%.

As a result the farming community is switching over from agriculture to non-agriculture 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. Even in rural segment, progressive and visionary farmers are becoming rich and the traditional farmers 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.
- The demand for the agro-produce and horticulture produce like fruits, vegetables, flowers, dairy products, meat etc. is increasing. As a result the opportunities for agro-processing value addition activities are increasing.
- There is national and international demand for bio-fuel, which has diverted growing of food crops. There is a need to think about Global Warming and Green Agriculture from a new perspective which is inclusive of sustainable development
- Agriculture – strengthens the farmers and brings all open areas under its cover.
- Involvement of rural youth in high-tech agriculture and agro processing industries – young educated farmers start –up micro processing enterprises at local level.

- Involvement of Public Leadership and future generation through an integrated perspective.
- The rural to urban migration has left uncultivated land in rural areas. This had encouraged corporatization of farming ignoring the farmer's stake in agriculture.

The climate Smart Agriculture can convert these challenges into opportunities through creating a win-win situation, reaping benefits to all the concerned stakeholders.

The public governance system – both elected and non-elected need to reach out to farmers and youth and provide them with sustainable development. 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 alongside organizations responsible have failed to take into account this issue. .

As mentioned, in fact, there are vast waste lands, which 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 interdependence and calm the unpredictable weather.

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. In Africa, this is due to re-

current droughts and internal turmoil.

India's share of arable land in the world is 11.5% (next to USA). There is ample 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 countries like 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.

LEADERSHIP FOR GREENER AGRICULTURE

Global Warming is a threat, but it can be converted into an opportunity. It is possible to make happen a win-win situation for all, if all efforts are channelized 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 to tehsil or even from village to village

through and locally developed acceptable Action Plan based on all different dimensions mentioned above with farmers 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- needs to be ignited and motivated to focus on farmers. 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 unsurmountable. But in reality, this is not so. It requires determined and persistent efforts to overcome these obstacles. A cohesive action with a common goal in mind can lead us to comprehensive prosperity, despite the adverse impact of Global Warming.

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 should be to overcome this challenge and convert it into an opportunity.

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

- 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

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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 nonprofit 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. Dr. R Gopichandran, is the Honorary Secretary and CDR Ashish Mittal, Indian Navy & Shri Shalin Shah serve as Joint Honorary Secretary

Website : www.nccsdindia.org

CENTRAL RESEARCH INSTITUTE FOR DRYLAND AGRICULTURE

CRIDA is a National Research Institute under the Indian Council of Agricultural Research (ICAR) established in 1985 with a mandate to carry out basic and applied research in rainfed farming. The Institute also undertakes National/ International Collaborations and Consultancy Projects. All India Coordinated Research Programmes (AICRPs) of ICAR on Dryland Agriculture and Agrometeorology with 25 partners each are in CRIDA. This is the lead Institute and the National Nodal point for the National Initiative on Climate Resilient Agriculture (NICRA) which is being implemented at large number of Research Institutes of ICAR, State Agricultural Universities and 100 KVKs.

Director of CRIDA is Dr. Ch. Srinavasa Rao and Dr. Mahaswari is Principal Investigator of CRIDA.

Website: www.crida.in

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

The Indian Council of Agricultural Research (ICAR) is an autonomous organisation under the Department of Agricultural Research and Education (DARE), Ministry of Agriculture, Government of India. Formerly known as Imperial Council of Agricultural Research, it was established on 16 July 1929 as a registered society under the Societies Registration Act, 1860 in pursuance of the report of the Royal Commission on Agriculture. The ICAR has its headquarters at New Delhi.

The Council is the apex body for coordinating, guiding and managing research and education in agriculture including horticulture, fisheries and animal sciences in the entire country. With 97 ICAR institutes and 47 agricultural universities spreaded across the country, this is one of the largest national agricultural systems in the world.

The ICAR has played a pioneering role in ushering Green Revolution and subsequent developments in agriculture in India through its research and technology development that has enabled the country to increase the production of food grains by 4 times, horticultural crops by 6 times, fish by 9 times (marine 5 times and inland 17 times), milk 6 times and eggs 27 times since 1950-51, thus making a visible impact on the national food and nutritional security. It has played a major role in promoting excellence in higher education in agriculture. It is engaged in cutting edge areas of science and technology development and its scientists are internationally acknowledged in their fields.

Website : www.icar.org.in

HOW TO USE THIS BOOK

This book has chapters related to Water Cycle, Soil Management, Energy Saving and Supporting Activities – in informative manner. The farmers shall have to be guided based on local situation and follow steps suitable from suggested ideas.

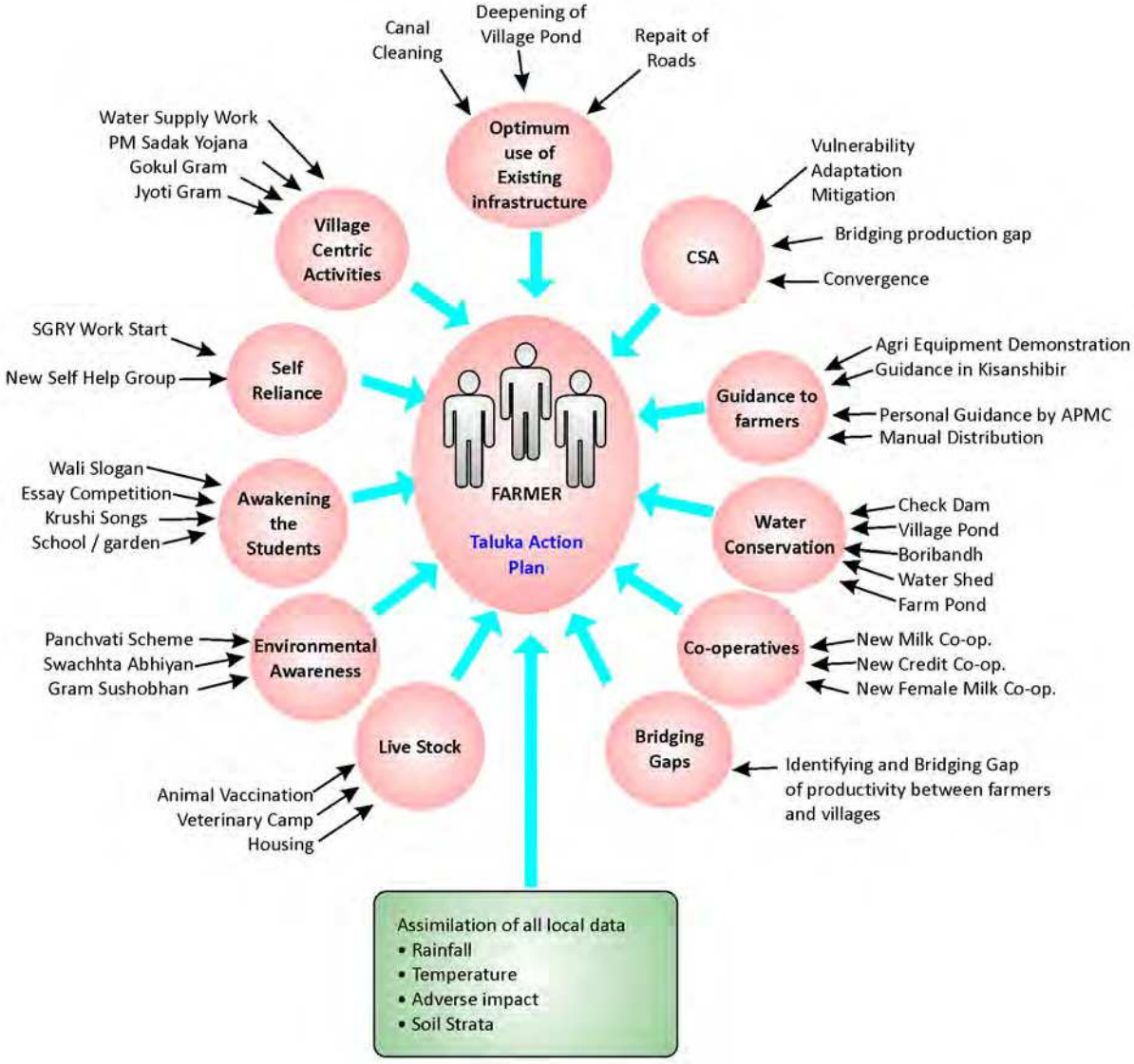
The Contingency Plan and Livestock Management are written in "Instructional Manner" – farmer can follow same straightaway.

Most important is that all stakeholders – agri. scientists, local extension team, KVK centres, input dealers, farmers and local elected and non-elected leaders of administration – need to remain alert and observe the changing pattern of weather and advice. If this is done, there will be no problem of sustainability of crops or livestock but if the care is not exercised as recently happened in Telangana where it is reported that planting of seeds was done when soil did not have sufficient moisture and so the germination failed. In the arena of climate change – decision of sowing is very important as monsoon was tending to get delayed. This requires careful attention and guidance by Agriculture Administration.

The Author also welcomes readers to share their own successful experiences as well as failures with analysis - this will help others. The email is drkiritshelat@gmail.com and postal address is Dr. Kirit N Shelat, Executive Chairman, NCCSD, Patel Block, Rajdeep Electronics Compound, Stadium Six Roads, Navrangpura, Ahmedabad – 380014, Gujarat, India.

DR. KIRIT N SHELAT

Taluka Action Plan



National Council for Climate Change,
Sustainable Development and Public Leadership (NCCSD), Ahmedabad
Patel Block, Rajdeep Electronic's Compound, Near Stadium Six Road,
Navrangpura, Ahmedabad-380 0014
Phone/Fax: (00 91 79) 26421580 • Mobile: 091 9904404393
Email: drkiritshelat@gmail.com, Website: www.nccsdindia.org

Sahitya Mudranalaya Pvt. Ltd., Ahmedabad-22 • Email : smpl99@gmail.com