Drought stress management in agriculture: Status, challenges, opportunities & way forward

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Outline

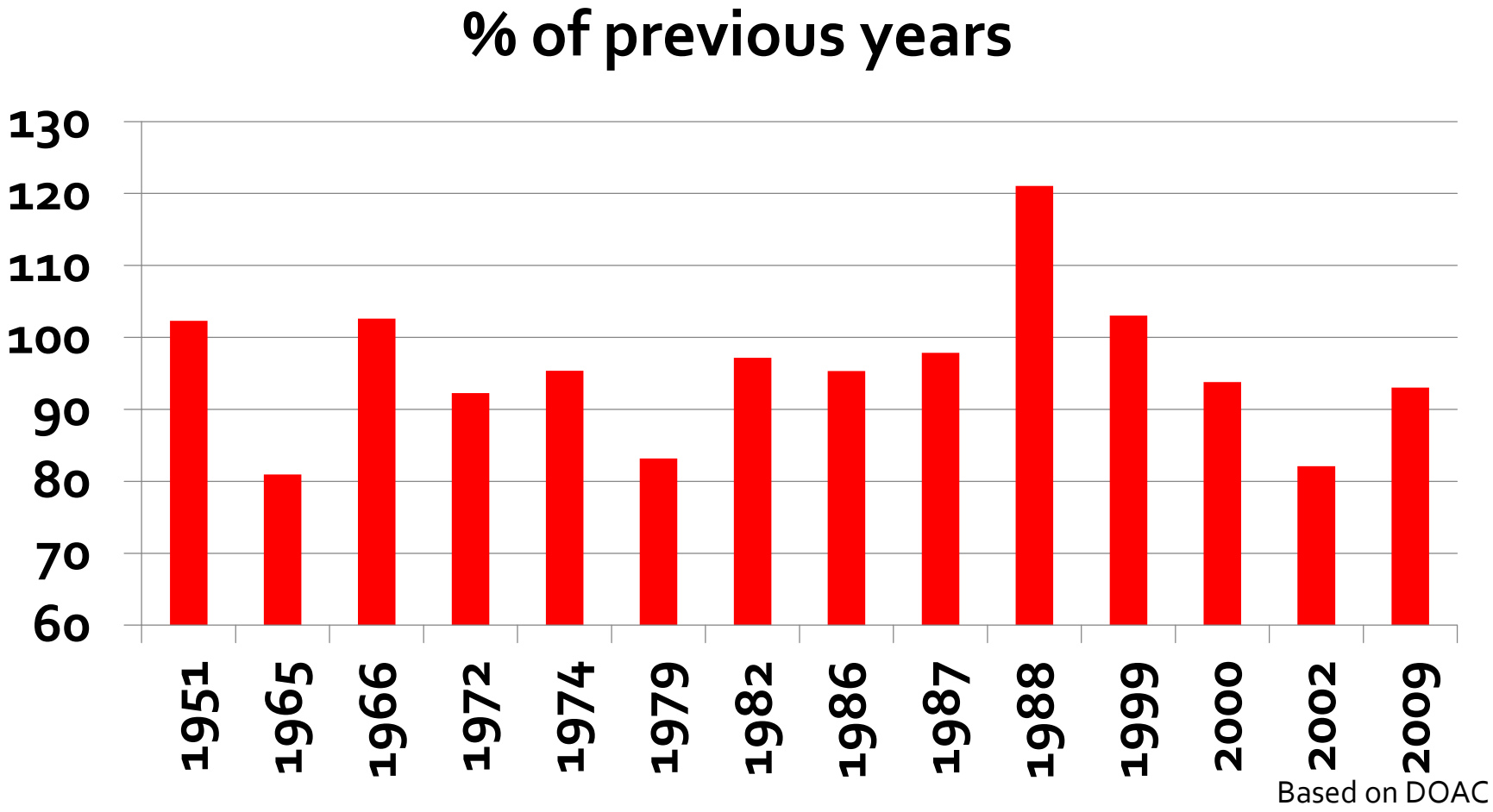
- Drought: the past
- Institution evolved in dealing with drought
- Drought stress management strategy
- Challenges
- Opportunities
- Way forward

Drought Management

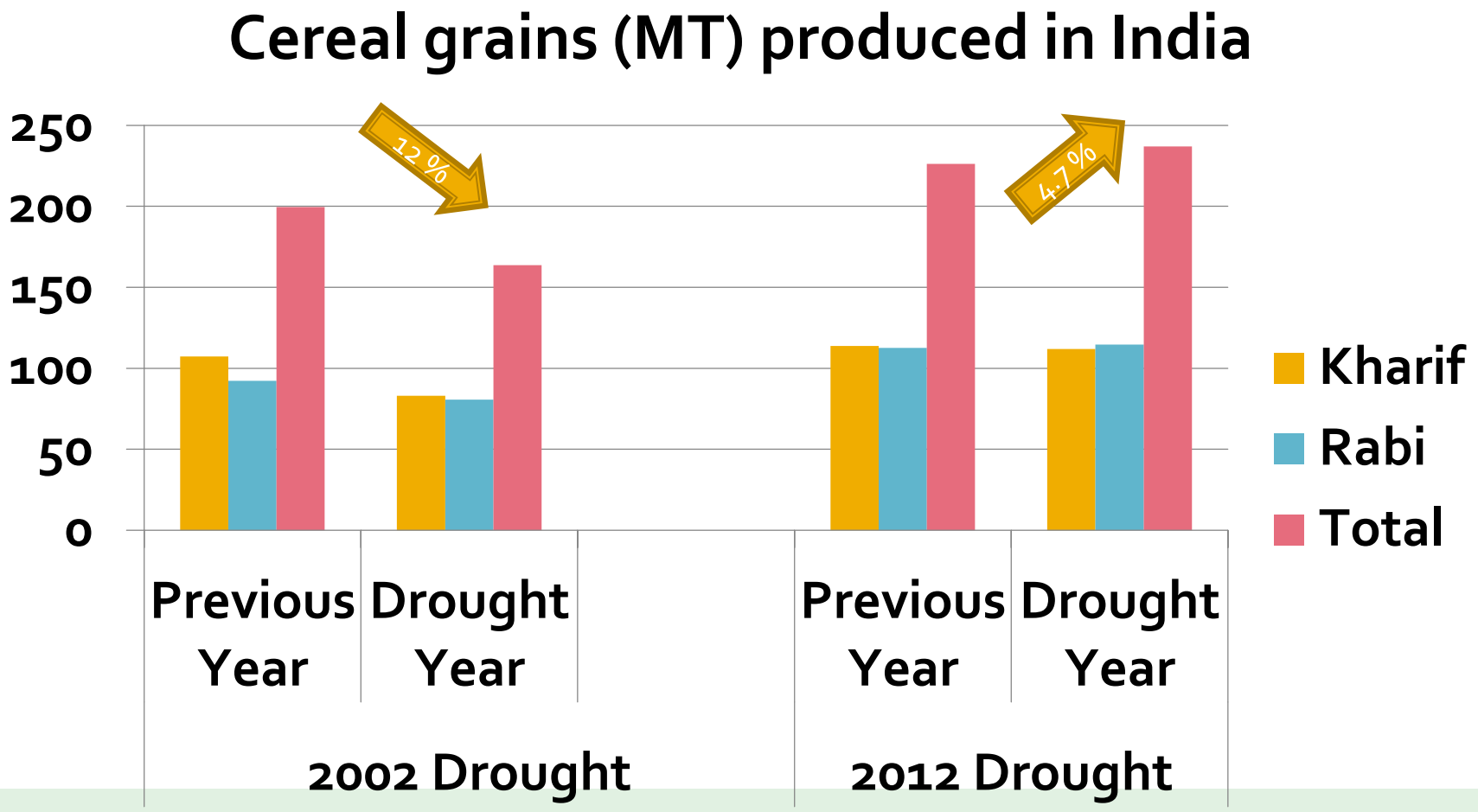
- Drought:
  - A phenomenon featured by water deficit sufficient enough to cause adverse effect on productivity of crop plants and livestock and on livelihood.
- Management issue:
  - Adverse effect of drought can be minimized
  - If attended systematically through institutional setup for monitoring, prediction and mitigation

- In the past, India had 24 large scale droughts 1891, 1896, 1899, 1905, 1911, 1915, 1918, 1920, 1941, 1951, 1965, 1966, 1972, 1974, 1979, 1982, 1986, 1987, 1988, 1999, 2000, 2002, 2009 and 2012 with increasing frequencies during the periods 1891-1920, 1965-1990 and 1999-2012.

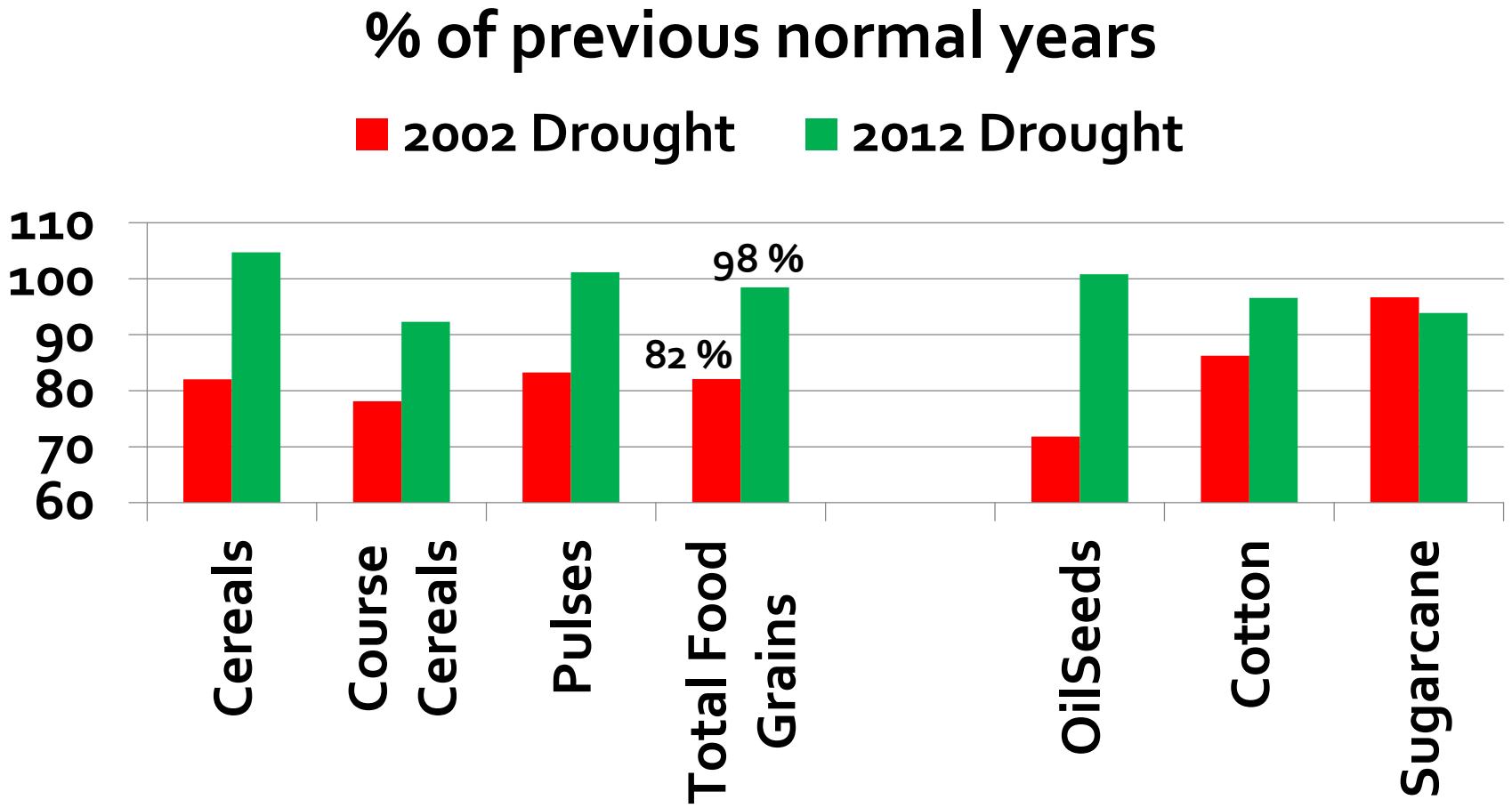
Food grain production: during drought years



Resilience imparted by institution and technology?



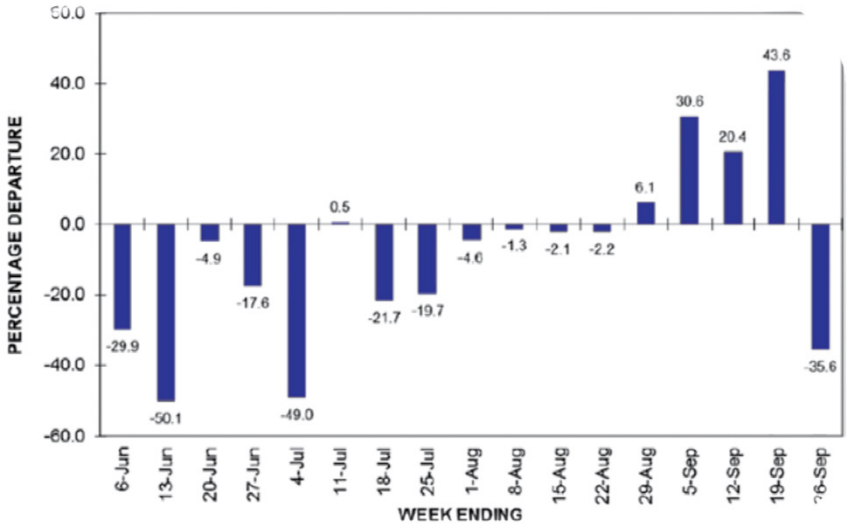
Impact of drought years on crop production



Rainfall Deficit in 2012

- Cumulative percent departure of rainfall
  - negative throughout the rainy season with greater deficit in the first part of the season.
  - ranged from -5.5% to -42.3%
  - Deficit during the critical month of July

(NRAA 2013; IMD)



Impact of drought 2012

- Most affected states
  - Maharashtra, Karnataka, Gujarat and Rajasthan.
- Excessive ground water extraction & high cost
  - Lowering of submersible pump by 3-4 meters,
  - replacing of low HP motors with higher HP
  - Excessive consumption of electricity /diesels

As on Sept 2012; NRAA, 2013

Impact of drought-2012 on area sown to crops

- Shortfall in area coverage compared to corresponding period of previous year as on 27th of July 2012 increased to -9.94%

Crop	Areas sown(Mha)			
	Normal	2012-13	2011-12	Decrease
Rice	39.1	37.32	38.8	-1.48
Coarse Cereals	21.56	17.59	20.11	-2.52
Pulses	10.65	10.34	11.41	-1.07
Oilseeds	17.59	17.77	18.12	-0.35
Sugarcane	4.71	5.29	5.1	0.19
Cotton	11.18	11.73	12.14	-0.41
Jute+Mesta	0.92	0.88	0.92	-0.04
Total Kharif area	105.7	100.92	106.59	-.5.68

(NRAA 2013)

Milestones in institutional setup

Programs	Year	Detail
DPAP	1973	Drought Prone Area Programme
DDP	1977	Desert Development Programme
	1993	H.Rao Committee
NARP	1979	Agroecological Regions NARP
	1989	Agroclimatic Regions
NWDPRA	1990	National Watershed Development Project for Rainfed Areas
AER	1992	Agro Eco Regions NBSSLUP
NWDP	1995	National Watershed Common Guidelines
IWDP	1995	Integrated Waste Land Development Programme
NATP	2004	Production system approach
NRAA	2006	National Rainfed Area Authority
IWMP	2008	Integrated Watershed Management Programme
RAPI	2012	Rainfed Area Priority Index

Drought Management Strategy (NDMA)

Information for Decision Making	• Meteorological Hydrological, Agricultural Information from measurements/observations-Ground based and Remote Sensing
Policies and Institution, Assessment, Communication	• GOI & SG Procedures • DAC-goi, Nodal Centre • IMD, ICAR,CWC, NRSC, DST… • Droughtindicators, criteria, NCFC, NCMRWF
Basket of risk management options	• Preparedness, Monitoring, Early Warning Systems, Contingency, Mitigation Strategies, Agril, Hydrological, Socio-economic
Action by decision makers	• Declaration • Immediate measures; Loss estimation, Mobilizing funding, Administering Relief • Long term measures, EWS, Drought-resistant technologies, Improved water management, sustenance, Crop livestock Insurance

Source: DOAC

Not all is well

- Agricultural production in drought prone areas like Aurangabad Division was severely affected

- Losses in *kharif* crops 21-64%
- Losses in *rabi* crops -54 to 70%

Horticultural crops severely affected

District	Total Area	Productive Area	Completely Wilted Area	Affected Area
Aurangabad	20733	12376	532	11712

Dried Citrus Orchard -May 2013

8 year old mango orchard -May 2013

Livestock Shelter-Pimpalwadi-Karjat

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Challenges: Food production

- The food production needs to be doubled by 2050 with
  - no area expansion in agriculture
  - declining productivity of land
  - no/less impact on environment
  - less water for agriculture due to
    - Population growth
    - Expansion of industries
    - Climate change

Even without climate change there can be drought like situations

- Millennium Ecosystem Assessment projects
  - a doubling of domestic water withdrawals in Sub-Saharan Africa, and a 20% to 90% increase in Asia, between the 1990s and the mid 21st century.

Managing Drought: Time of precipitation

Delay	Consequence
I. Delayed onset Maximum of three weeks from normal date for the given region.	This happened in North-west India in 2002 and North-west and North-east India in 2009.
II. Early onset and sudden breaks.	This scenario happened in some parts of the country in 2009.
III. Early withdrawal of monsoon	By last week of August and causes stress during maturity of crops.
IV. Delayed withdrawal or extended monsoon.	May damage matured kharif crops at the harvesting time as in 2012 but benefit sowing of subsequent rabi crop.

Contingency plan needs to be scaled up

Managing environmental foot prints

- Water saving technologies such as plastic mulch can leave tonnes of plastic in soil
- If not cleared after use can contribute to declining productivity of land and environmental pollution


Drought stress management in agriculture:
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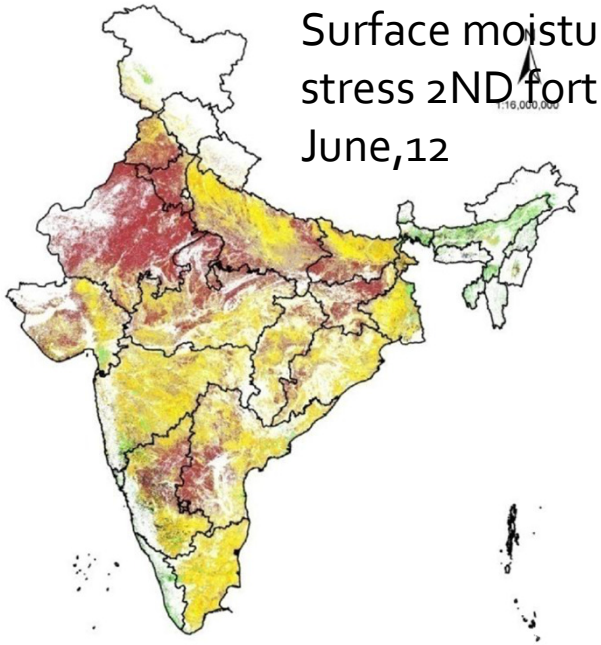
Tools for prediction and monitoring

- National Agricultural Drought Assessment and Monitoring System (NADAMS)
  - to use remote sensing and meteorological data for drought assessment
  - developed by NRSC , ISRO
  - Managed by MNCFC, Department of Agriculture & Cooperation



Surface moisture stress 2ND fortnight June,12

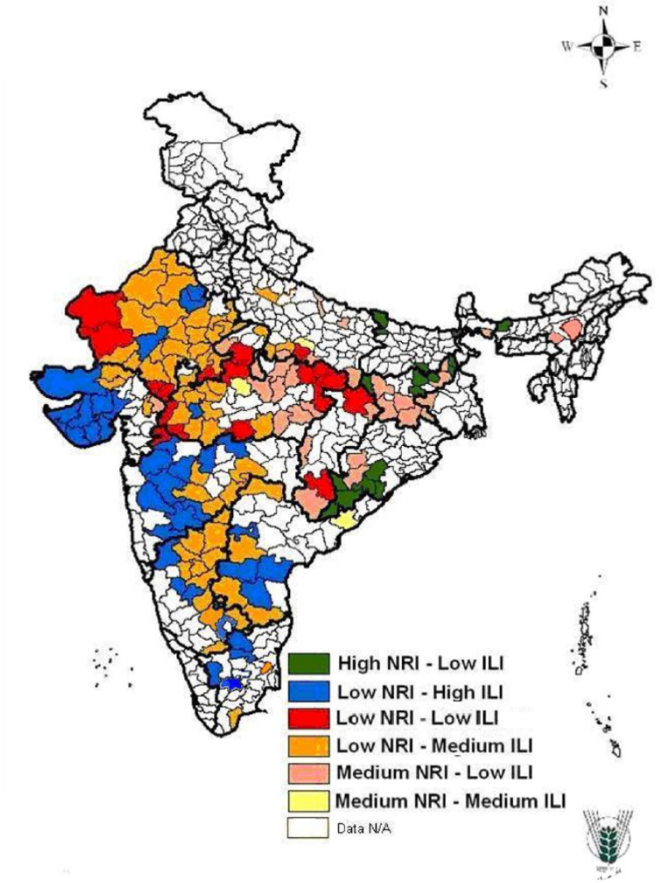
MNCFC |Agricultural Drought Assessment Report, June 2012

Clarity on drought environments: Prioritized drought prone areas

NRAA, CRIDA and IASRI together have come up with "Rainfed Areas Prioritization Index" (RAPI)
by combining

- natural resource index (NRI) and
- integrated livelihood index (ILI).

- 167 districts, the top one-third among 499 as prioritized districts.



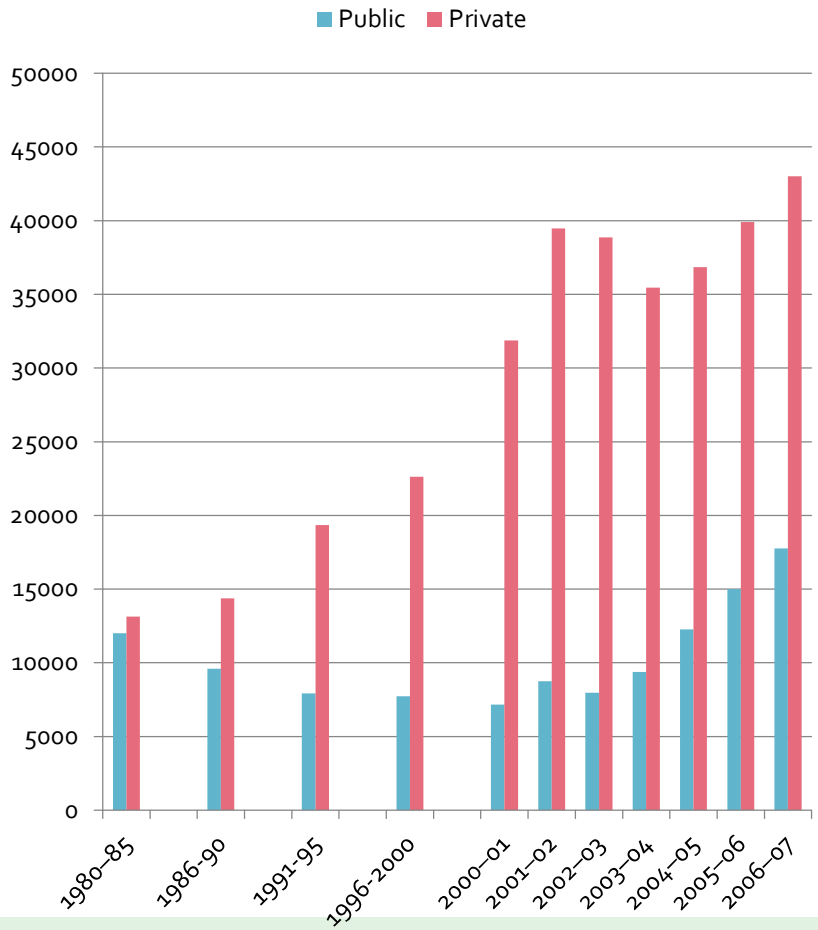
NRAA, 2012

National Watershed Projects from 1995-96 to 2007-2008

Name of Scheme	No. of project sanctioned	Area covered (in lakh ha.)
DPAP	27439	130.2
DDP	15746	78.73
IWDP	1877	107
Grand Total	45062	322.93

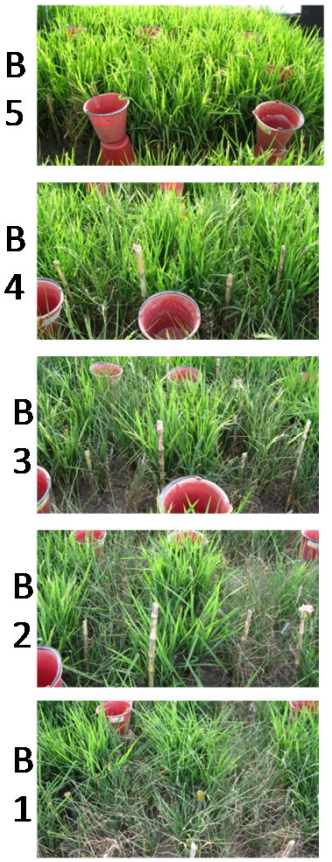
Private investment

- Increase in cost of agriculture assets
- Increase in income in watershed areas
- Increase in food price
- Increase in private investment
  - Water saving resource management technologies
  - Genetic improvement of water productivity of crops



Advances in science

- Molecular approaches for drought tolerance
- Phenomics tools to understand drought responses of plants
- Bioinformatics
- Conservation Agriculture
- Technologies to mitigate stress
  - Growth regulators; phytohormones

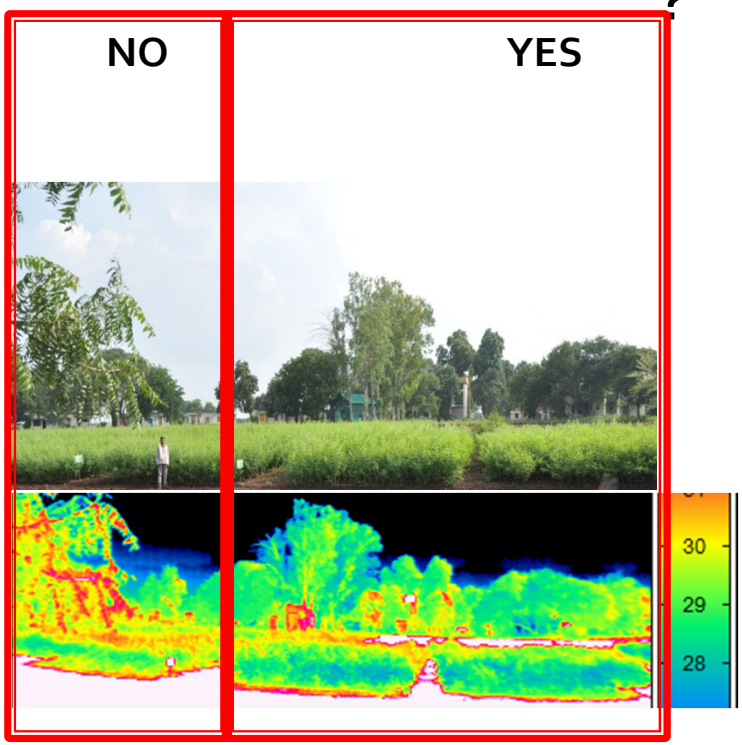


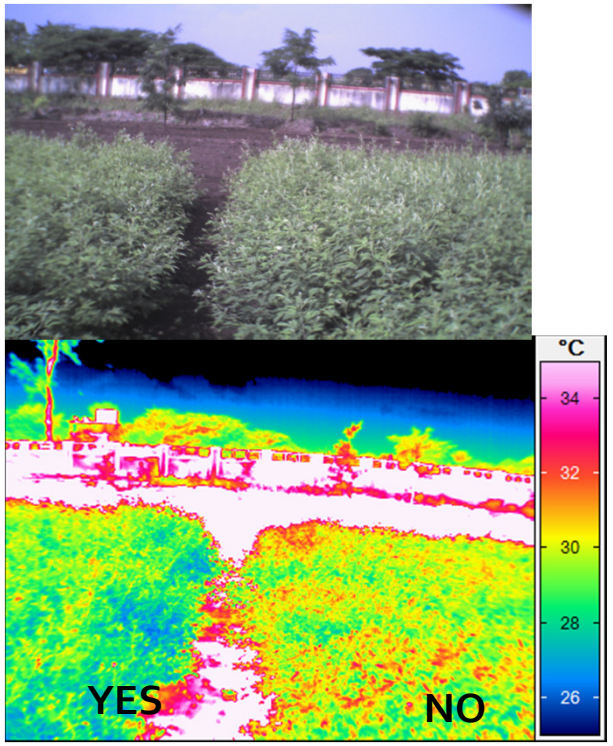
Drought tolerant IR64 in field

Uga et al. 2013. Nature Genetics

Advances in science:
IR Imaging to track - invisible genotypic difference

Response to additional irrigation ?





Canopy cooler by at least ~2°C in variety responding to additional irrigation- indicate more transpirational cooling and scope for trait based screening in crop breeding for limited soil water environments

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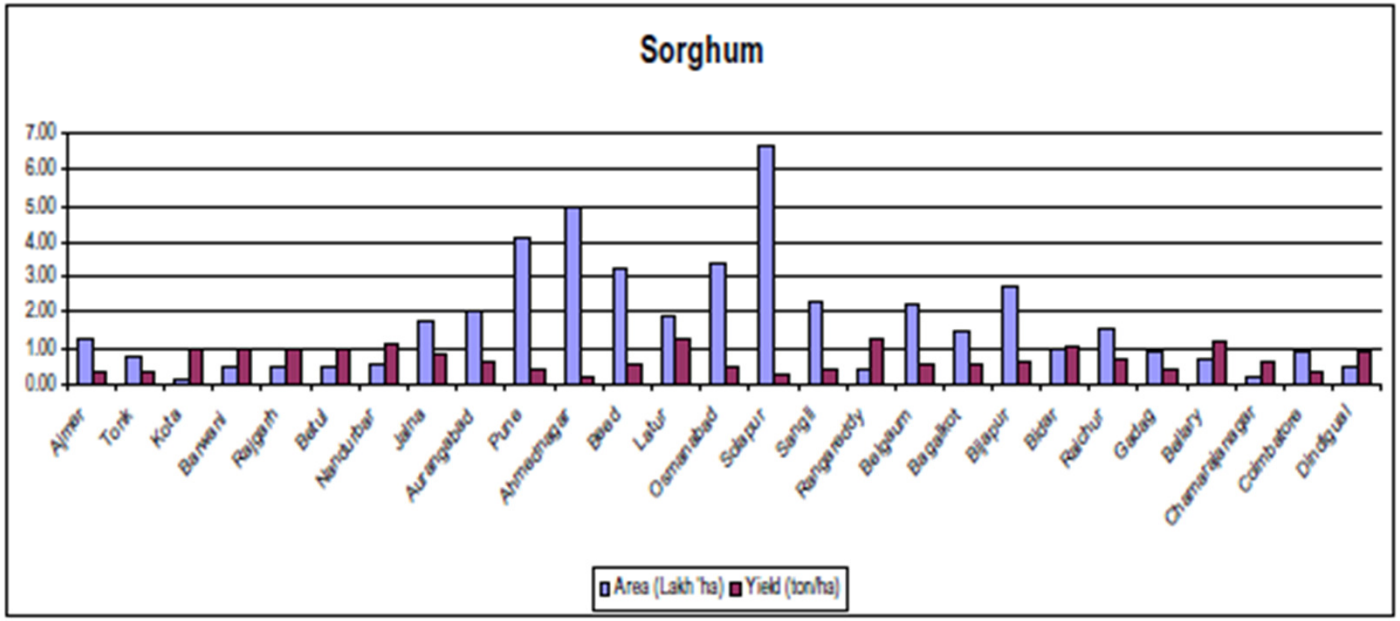
Possible approach to accelerate impact of research

- Problem identification and prioritization;
- Convergence of existing technologies to match the need;
- Generation of need-based viable technologies using the holistic farming system approach;
- On-farm assessment and evaluation;
- Feedback on the technologies;
- Refinement of technologies, if necessary;
- Ensuring timely availability of inputs.

Enhancing productivity: of crops in rainfed areas



NRAA 2012

Right commodities at right time and right place in cluster of years covering drought period

- Scientific intervention to induce flowering and fruiting when desired

- Focus on goal to manage drought than charity

Wild relatives as source of tolerance to drought:
Unexplored treasure of genes?

School of Drought Stress Management
National Institute of Abiotic Stresses Management

Exploring wild treasures of drought tolerance to enhance value of marginal land

- Nopalitos, the young tender lobes (stems) of spineless cactus varieties, are used for **fresh consumption, stir-frying, pickling, and roasting**.
- Tunas, mature cactus fruits, range from ~100-200 grams in mass, and **about 13% in sugar content (among commercial types).** A wide range of colors exist -- US consumers prefer deep purple fruit, however other countries prefer orange, green, white, or yellow.
- High sugar levels are supplemented by a wide range of flavors, including watermelon, banana, peach, and others.
- **Both traditional and modern medicine associate cactus consumption with reduced diabetes,** representing a new means to prevent diet-related diseases. Nopalitos also contain a high level of complex polysaccharide (fiber), well-established to have many salubrious effects.
- An insect parasite of cactus, the cochineal (Dactylopius coccus), produces a deep red pigment (carminic acid) that was the first color-fast red dye used in Europe. **Recent interest in natural dyes has driven cochineal prices to $80/kg.**
- **Opuntia has long been a stopgap crop used as livestock forage in times of drought**.

Market for progress: Can dry land crop fetch more premium ?

Conservation agriculture

- Water saving technologies
  - Raised bed
  - Alternate furrow irrigation(partial root zone irrigation)
- Assessment of
  - Water production function for
    - Each crop
    - Each soil type
- Plant response based regulation of irrigation
  - Sensors, precision
  - Extractable soil water for growth
- Fertilizer use
  - Unused during drought season

Other issues

- Technologies for dry land horticultural crops
  - Water conservation
  - Soil conservation
  - Water storage
  - Minimizing loss of water
- Forage for big animals
  - Common grass lands
  - Transport of crop residues?

Augmenting contribution of unsung lords of dry land

Small ruminants provide much needed livelihood support to the landless and weaker sections and hold considerable potential for commercialization. A stable sheep population in the last two decades produced around 40 million kg wool annually, of which only 4 million kg is of fine quality. Goat population grew faster than any other species of livestock and has been a major source of meat

(Working group report 2012. Animal Husb&Dairying)

Sharing task, ensuring synergy

- Institutes for basic research at centre
  - basic, strategic, and anticipatory research
  - in line with national priorities,
- Institutes in the region
  - applied and adaptive research
  - location-specific problems,
- Private sectors, CG institutes
  - Proof of concepts; product development
  - Validate technology on shelf

National Institute of Abiotic Stress Management

NIASM(2009)

An unique institute in the making

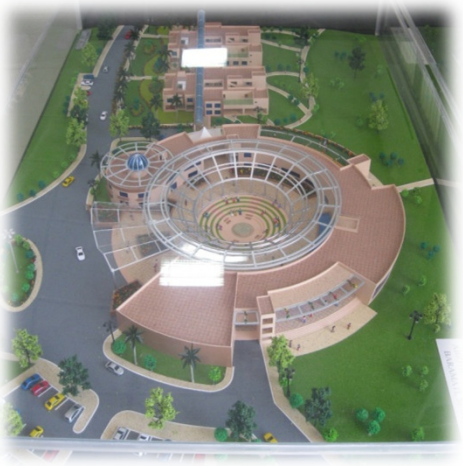
Abiotic stress

Water | Soil | Atmosphere

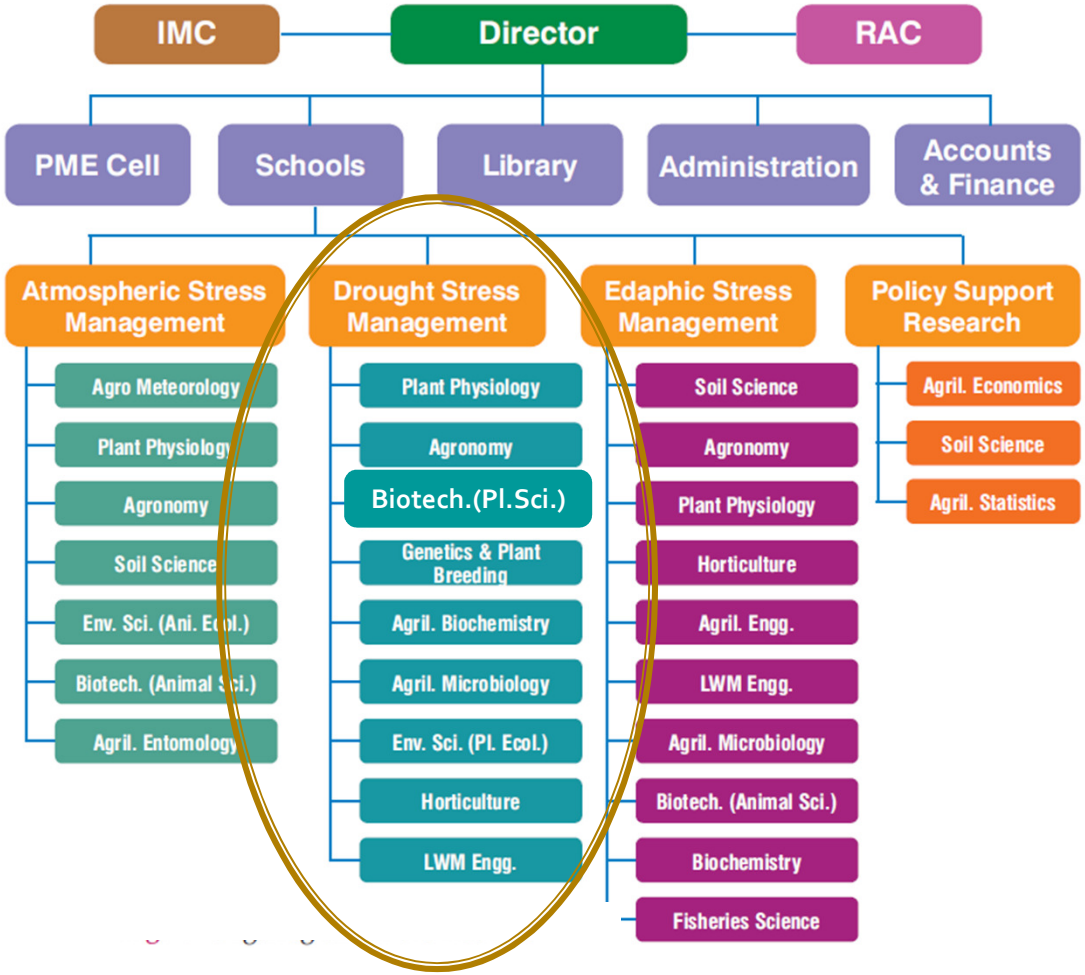
Excess or Deficit; Low or high

Across the commodities :crop plants, livestock, fish, avians

To scale up the capacity first and then prepare the young generation next

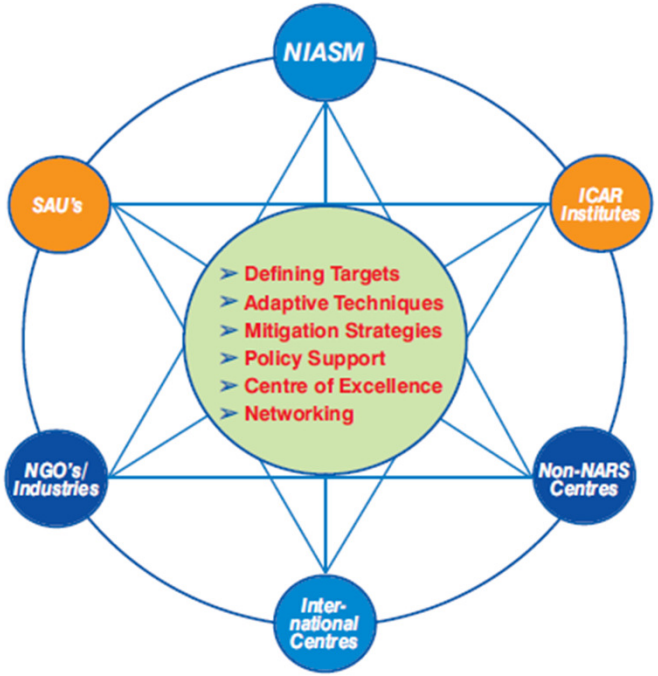


Multidisciplinary approach



Institute's strategy

- Enhanced clarity of target environments
- Identifying/developing adaptation options
- Mitigating stress
- Policy support
- Centre for education and research
- Platform for research network



Vision 2050 : NIASM

Drought Management:Outlook

- Institutions well evolved
  - Synergies can make great impact to
    - Learn
    - Manage
    - Recover
- Techniques for predictions are more robust if not perfect
  - Technology, Target Environment and Time for implementation crucial
- Technologies
  - Available, on shelf, need validation
  - Need reorientation
  - Emphasis on eco-friendly water saving technologies

ACKNOWLEDGEMENT

- ILSI
- CIMSANS
- ICAR
- NIASM