



Genetic Enhancement and Natural Resources Management for Enhancing Productivity, Sustainability and Resilience in Drylands

Dr. D.K. Yadava

Dr. G.P. Singh

Dr. G. Ravindra Chary

**Indian Council of Agricultural Research
Department of Agricultural Research & Education
Ministry of Agriculture and Farmers Welfare
Govt. of India, New Delhi**

**International Virtual Experts Meeting on Promoting Sustainable
Agriculture Development in Drylands**

Kingdom of Saudi Arabia, Riyadh August 10, 2020



Indian Agriculture at a Glance

- ❖ 17.74 % of world human population
- ❖ 4.2% of the World's water
- ❖ 2.4% of the world's area
- ❖ 140.1 m ha net sown area
- ❖ 52 % of net sown area is rainfed
- ❖ 142% cropping intensity
- ❖ 52% of workforce in agriculture
- ❖ 15.4% contribution to GDP
- ❖ 10.6% earning of total exports
- ❖ Large country with diverse biophysical and socioeconomic settings with diverse agroecologies- climates, seasons, soil types, production systems, farming systems
- ❖ Increase in frequency of extreme weather events
- ❖ Small & marginal land holdings (86.2%), poor coping mechanisms

Rainfed agriculture practiced in arid, semi-arid and sub-humid regions and accounts for 52% of the net cultivated area

Contributes about 40% of food production

- Coarse cereals : 83%
- Pulses : 81%
- Oil seeds : 72%
- Cotton : 67%
- Rice : 40%

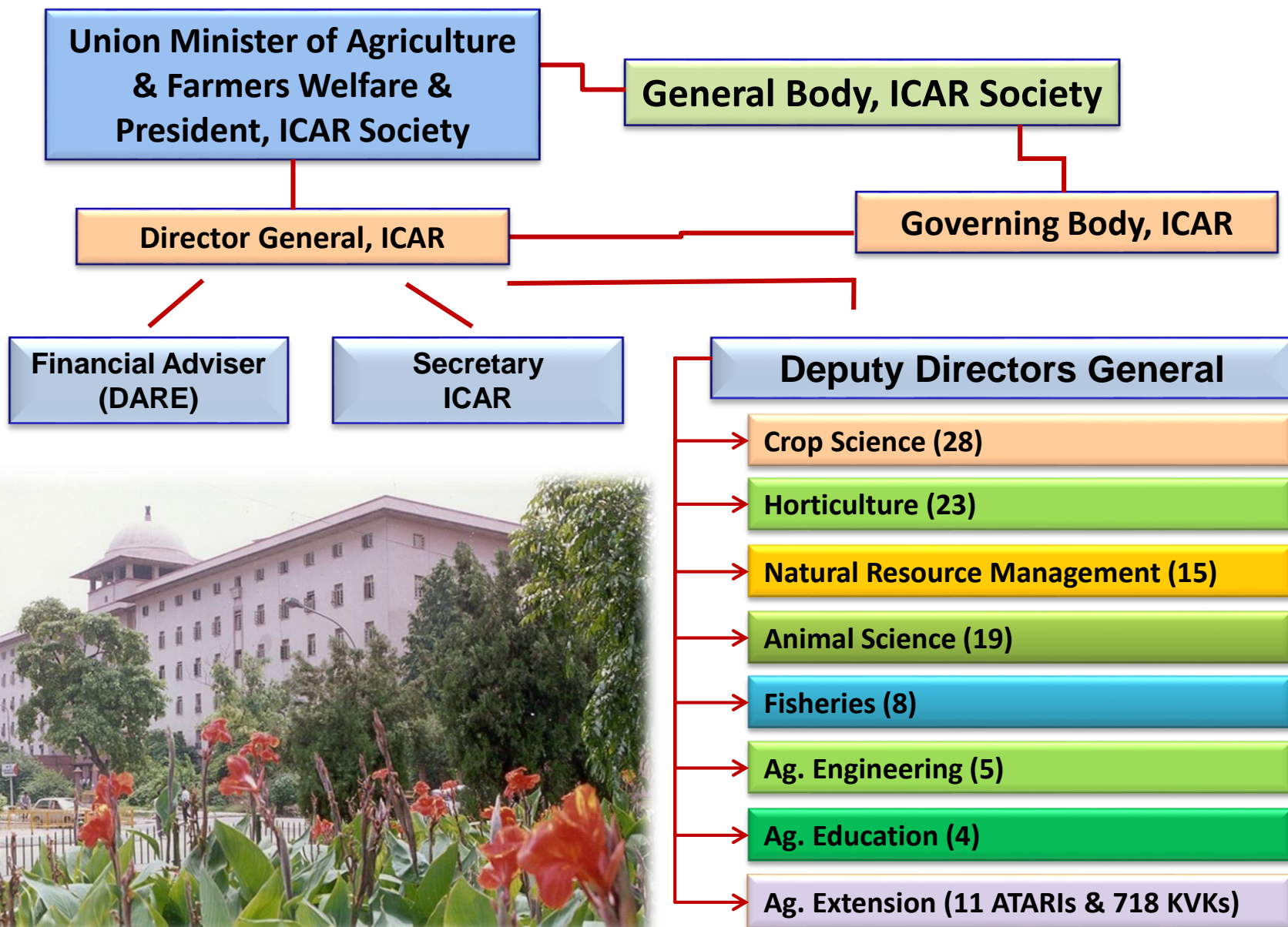
Change in Food Production Scenario in India

Item	1950-51 Production (million tonnes)	2019-20 Production (million tonnes)	Times Increase (X)
Food grains[!]	50.83	295.67	5.82
Pulses[!]	8.41	23.01	2.74
Oilseeds[!]	5.16	33.50	6.49
Cotton[!]	0.52	6.13	11.79
Sugarcane[!]	57.05	358.14	6.28
Horticulture[@]	96.56 (1991-92 level)	313.35	3.25
Milk[#]	17.00	187.70	11.04
Fish[#]	0.75	13.42	17.89
Egg (no. in billion)[#]	16.1 (1985-86 level)	103.30	6.42
Meat[#]	1.9 (1998-99 level)	8.11	4.27

[!] III Advance Estimates of 2019-20, [@] I Advance Estimates of 2019-20, [#] Figures for 2018-19



Indian Council of Agricultural Research



Diversification and Integration

Field Crops (85)

- Cereals (4), Millets (10), Pulses (12), Oilseeds(15), Commercial Crops (11), Forage Crops (17), Potential Crops (16)

Horticultural Crops (134)

- Fruits(28), Vegetables (48), Spices (12), Seed spices (10), Tuber Crops (11), Temperate fruits (10), Plantation crops (3), Flowers (8), Mushroom (4)

Animal breeds (199) & Fish Species (111)

- Buffalo, cattle , small ruminants
- 61 food fish and shellfish, 50 ornamental fish

NRM and Farm Mechanization

- Climate resilient agriculture
- Saline/alkaline/sodic soils, Arsenic affected, waterlogged/water stressed areas and cropping
- Small smart machines and agro- processing

Farmers Outreach

- 716 KVKs, all rural districts



Crop Varieties: 1969 - 2019

Crops	No. of varieties notified 1969-2019	No. of varieties released 2014-2019	Climate resilient varieties 2014-19	Biofortified varieties	MAS derived varieties
Cereals	2626	645	446	42	45
Oilseeds	864	183	183	4	1
Pulses	966	187	187	2	2
Fibre crops	364	92	89	-	-
Forage crops	187	81	81	1	-
Sugar crops	122	44	32	-	-
Others	35	2	2	Hort. 4	-
Grand Total	5164	1234	1020	53	48





Field crop varieties for drought/ moisture stress tolerant/ water stress/low rainfall condition released since 2014

Total: 137

CEREALS 75

Rice (32)

Wheat (19)

Maize(8)

Sorghum (4)

Pearl M. (7)

Little millet (2)

Kodo millet (1)

Finger Millet (2)

OILSEEDS 10

Soybean (2)

Groundnut (3)

Sesame (1)

Indian Mustard (2)

PULSES 18

Urdbean/ blackgram (1)

Pigeonopea/ Red gram (9)

Horse gram (2)

Cluster bean (Guar) (1)

Chickpea (3)

Lentil (2)

COMMERCIAL CROPS (6)

Cotton

Roselle

FORAGES (11)

Pearl Millet

Forage Sorghum

Cowpea

Fescue

Guinea Grass

Rice bean

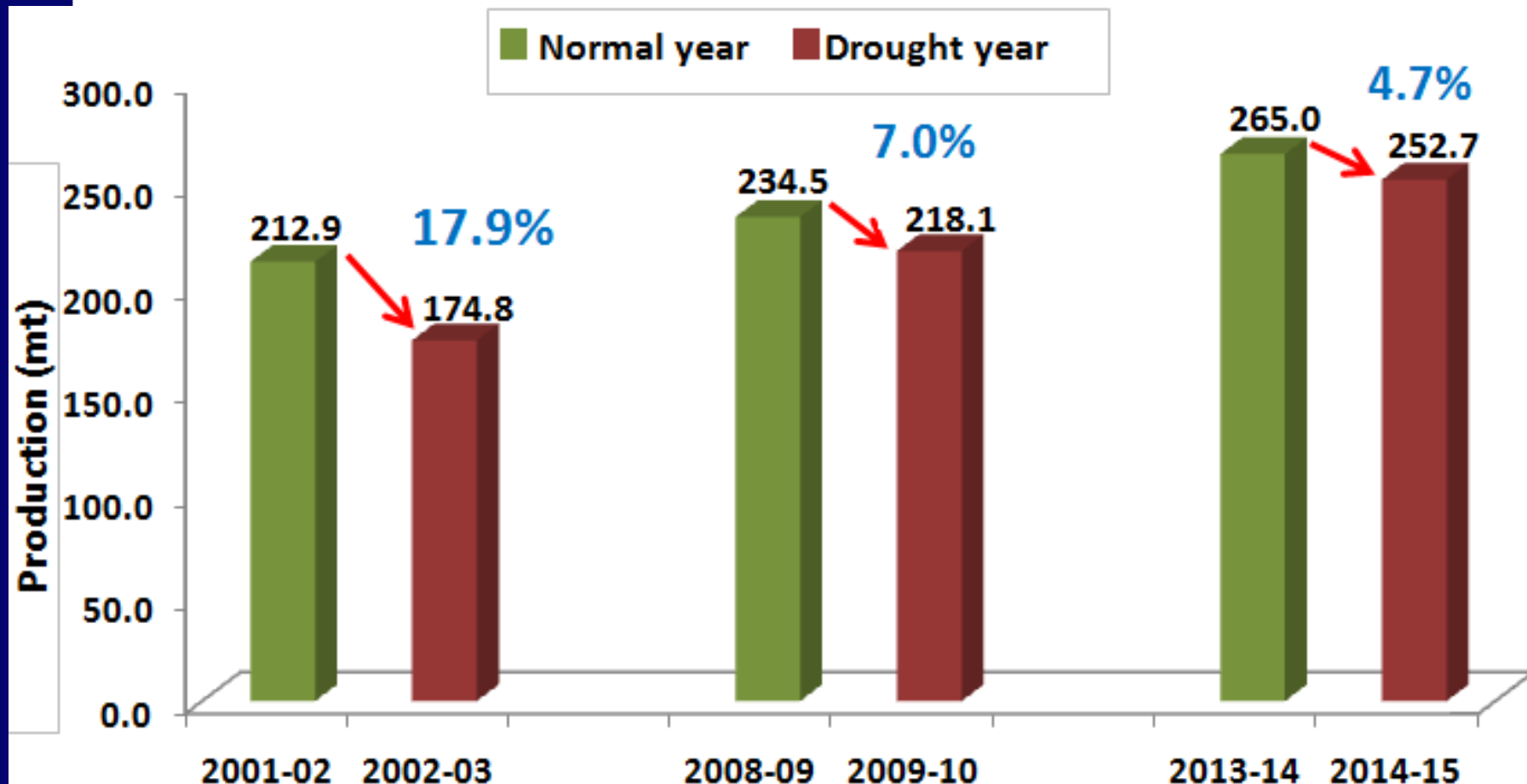
Marvel Grass

Anjan Grass

Forage Sewan Grass



Resilience of technology to withstand stresses (food grain production)





ICAR Varieties/Technologies Making Impact (A Few Examples)

- **Pusa Basmati 1121** – 1.5 lakh Crores of Rupees during (2008-2016); Net Export: Rs. 33000 Cr.; Net Profit Rs. 16700 Cr. per year
- **Sugarcane CO 238** (12% sugar recovery) – Rs. 28,795 crores gross value every year
- **Wheat HD 2967 and HD 3086 Area:** 10 million ha contributing to 50 mt production (50% of total wheat production in India). Licensed to 204 seed companies
- **Potato Varieties** - Rs. 57,512 crores gross value every year
- **Biocontrol** – Papaya mealybug affected 1500 ha; Saved about Rs. 1300 Cr.
- **CRRI Rice:** 133 varieties covering 18-20% of rice area of the country; Total Value worth Rs. 48000 Crore per year



Pulses Revolution :

Breakthroughs in Pulses Research and Seed Production

Particulars	Years			
	2016-17	2017-18	2018-19	2019-20
Production	23.13	25.42	23.40	23.01*
Total Imports	6.61	5.61	2.53	-
Availability	29.74	31.03	25.93	-
Total Exports	0.14	0.20	0.28	-
Total availability for domestic consumption	29.60	30.83	25.65	-

DES: Directorate of Economics and Statistics; DoC: Department of Commerce; * 3rdrd Advance estimate of DES

1. Development of > 900 HYV in pulses
2. Released 4 land mark varieties with unique characteristic:(Fe, Zn fortified lentil), IPA 15-03 (early maturity pigeonpea hybrid), Mungbean IPM 205-7 (Virat, a Super early mungbean variety), IPFD 10-12 (green seeded fieldpea varieties) .
3. Reduction in duration (Mung; 55/70D, lentil to 120/150 D & chickpea to 100/140 days.
4. Increase in seed size *Kabuli* chickpea (to 55/25 gram)
5. Development of Diagnostic Kits (*LYMVs PCR Diagnostic Kit* and Multiplex-PCR *LYMVs Mplex* for virus identification causing the most widespread YMV in pulses.
6. Development of *Trichoderma* based formulations (*Dalhanderma* 1,2)



Millets grown in India

Major millets



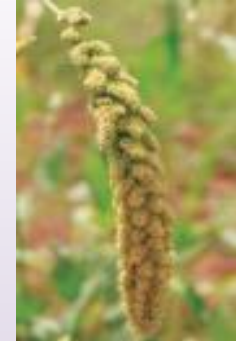
Pearl millet
(*Pennisetum americanum*)



Great millet / sorghum
(*Sorghum bicolor*)



Finger millet
(*Eleusine coracana*)

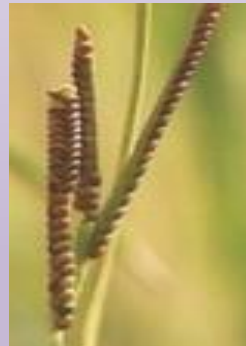


Foxtail millet
(*Setaria italica*)

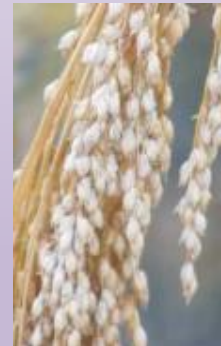
Small millets



Little millet
(*Panicum sumatrense*)



Kodo millet
(*Paspalum scrobiculatum*)



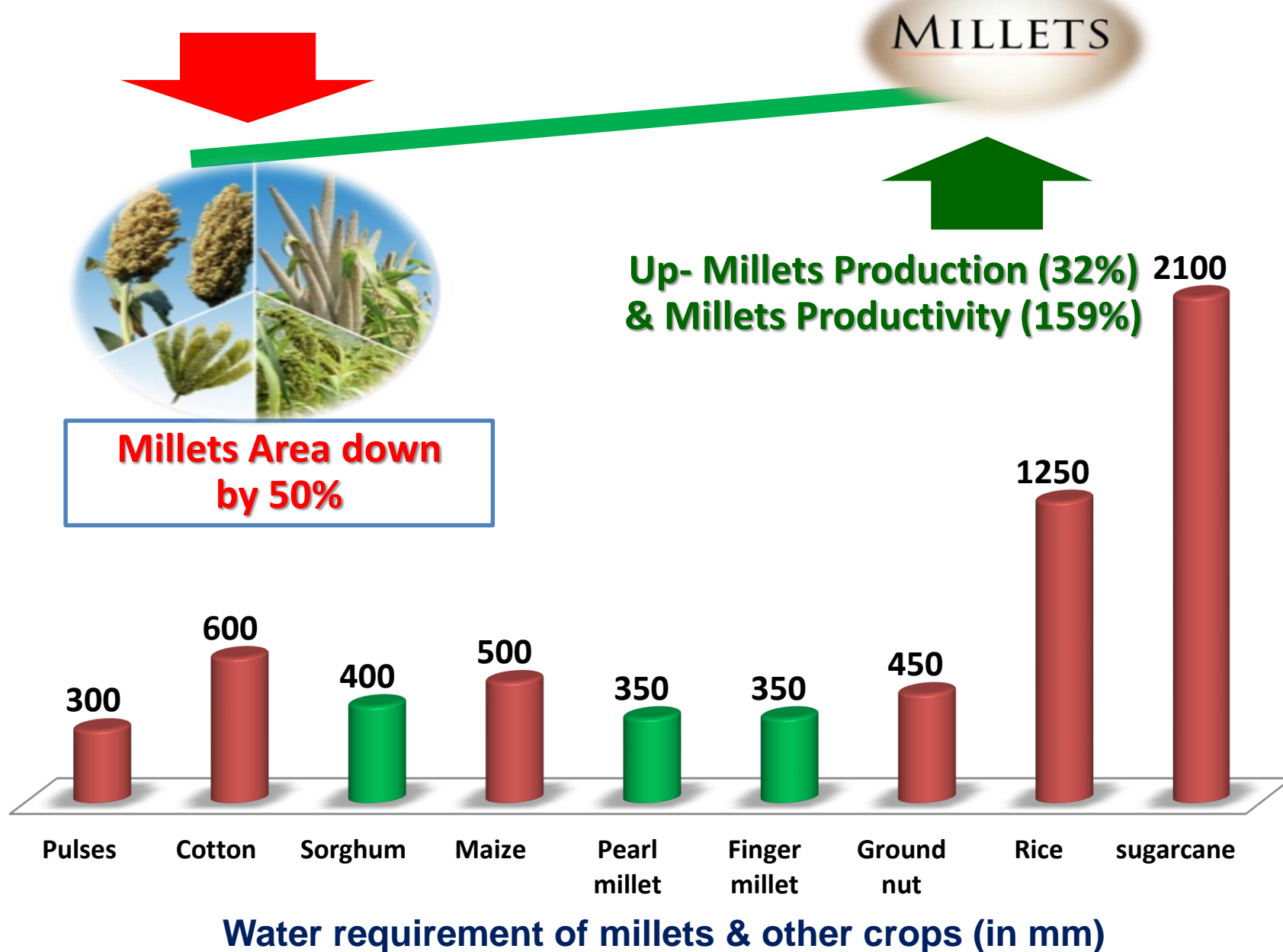
Proso millet
(*Panicum miliaceum*)



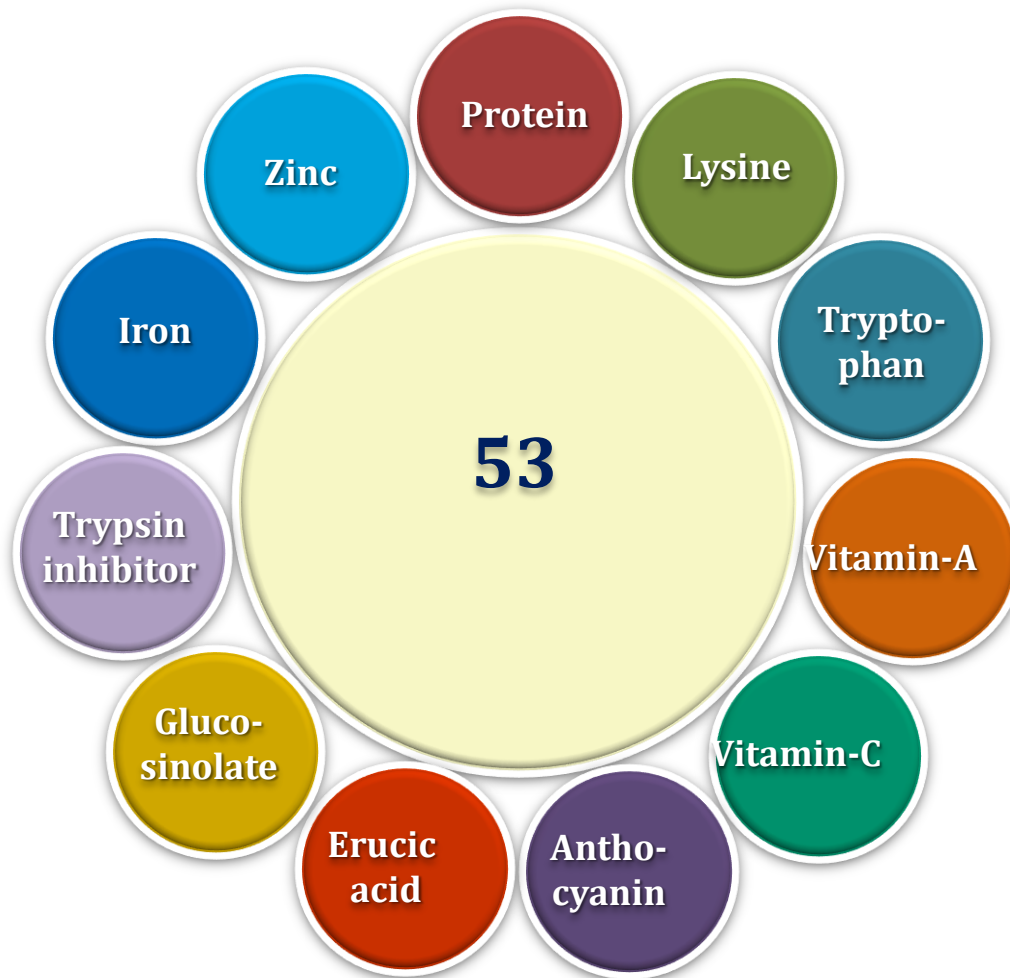
Barnyard millet
(*Echinochloa frumentacea*)



Water Requirement of Millets

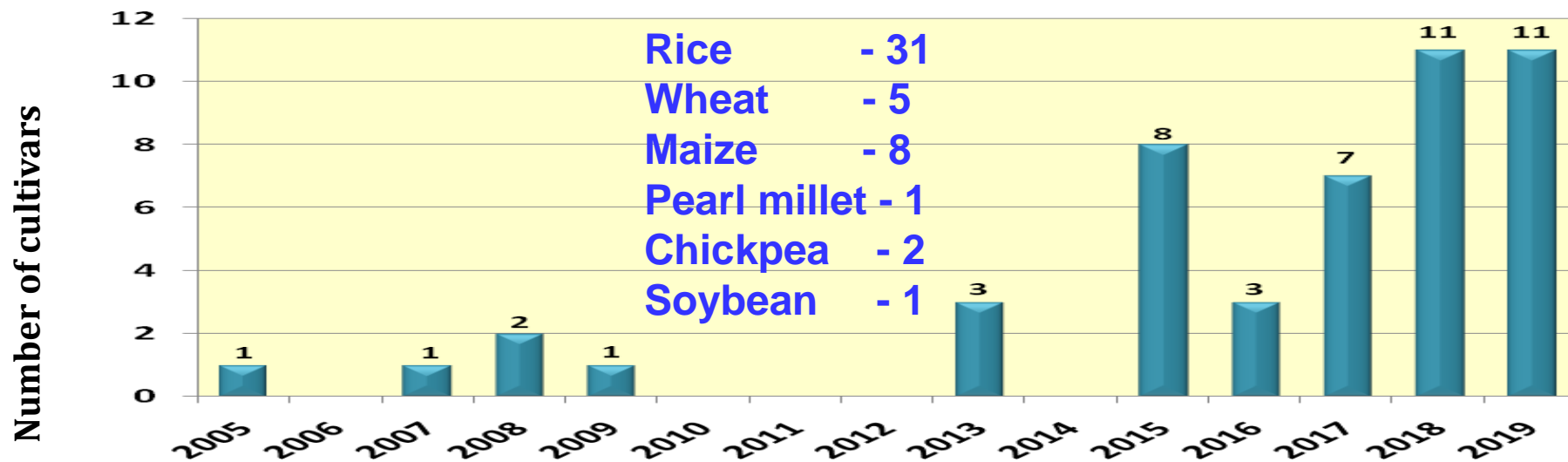


Biofortified Varieties: Sustainable Way to Alleviate Malnutrition

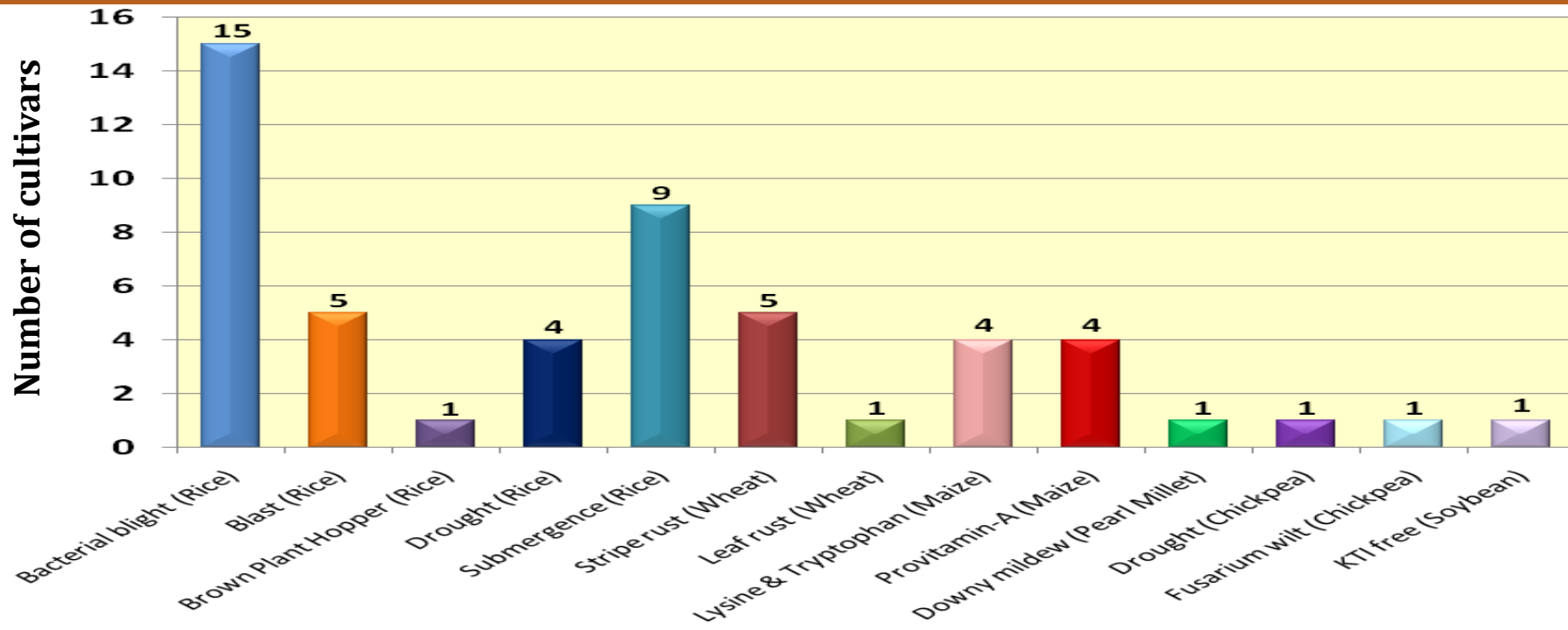


- **Rice (7)**
- **Wheat (17)**
- **Maize (9)**
- **Pearl millet (9)**
- **Sorghum (1)**
- **Lentil (2)**
- **Mustard (2)**
- **Linseed (1)**
- **Soybean (1)**
- **Horticultural crops (4)**

Total 48 of MAS-derived cultivars released in India



Number of cultivars improved for various traits using molecular breeding





Germplasm Conservation Status at National Genebank (March 31, 2020)

Indian Council of Agricultural Research



REDMI NOTE 5 PRO
MI DUAL CAMERA

Crop/Crop Group	Total Species	Total acc. conserved
Cereals	136	165966
Millets	28	59434
Forages	200	7261
Pseudo-cereals	55	7791
Legumes	109	66927
Oilseeds	84	60386
Fibre crops	77	15877
Vegetables	212	27082
Fruits & Nuts	68	289
M&AP & Narcotics	681	268
Ornamental	122	668
Spices and Condiments	28	3254
Agroforestry	191	1653
Duplicate safety Samples (Lentil, Pigeonpea)	-	10235
Total conserved (M&AP)		10771



Trait Based Breeding for Drylands

Early vigor

- Early leaf growth in seedling stage increases land shading and minimises water loss from the soil



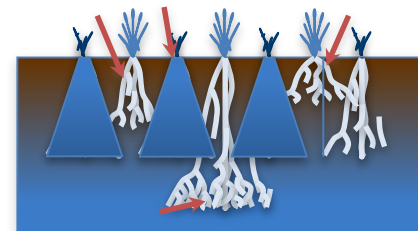
Tillering inhibition

- Tillering inhibition (*Tin* gene) reduces unproductive tillers under drought



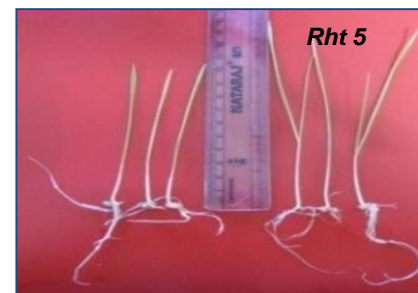
Deep roots

- Deep root system extracts soil from deeper soil layer



Alternative dwarfing genes

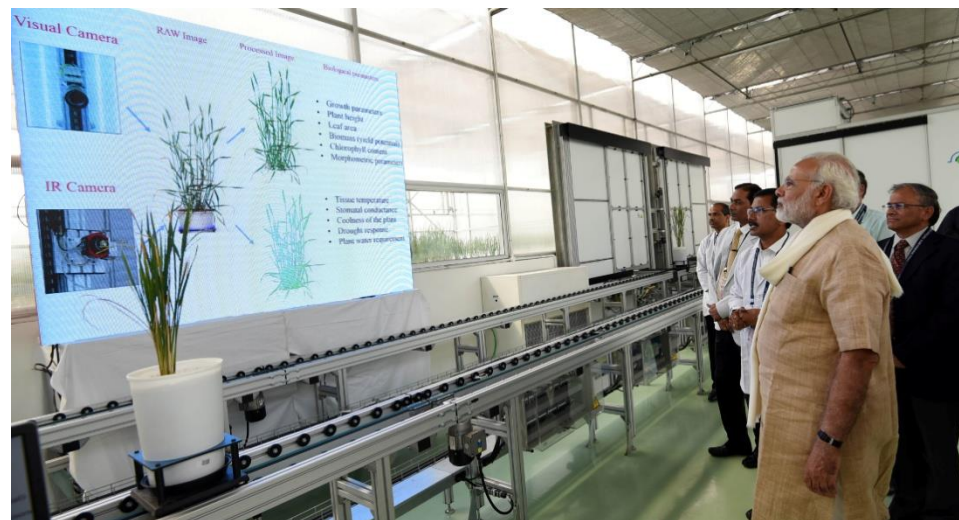
- Increased coleoptile length helps in emergence from deeper soil layer





Nanaji Deshmukh Plant Phenomics Centre, IARI, New Delhi

Indian Council of Agricultural Research



Shri. Narendra Modi, Hon'ble Prime Minister of India, inaugurating the "Nanaji Deshmukh Plant Phenomics Centre" on 11th October 2017 at IARI, Pusa, New Delhi

Drought tolerance phenotyping





Indian Seed Network

- ICAR Institutes (51), SAUs/CAUs (60/73), KVKs (717), Seed Hubs (218) (Pulses-150, Oilseeds-35, Millets-25, FPSPP, Seed Village Scheme)
- One national level organization viz. NSC (SFCI merged)
- 17 State Seed Corporations
- 25 State Seed Certification Agencies
- 132 Notified Seed Testing Labs (6 ISTA accredited and 16 have ISTA membership)
- ~500 large and medium size private seed companies

Indian Council of Agricultural Research (ICAR)

ICAR-Indian Institute of Seed Science

AICRP-NSP (Crop)

ICAR Seed Project

➤ BSP centres-41

➤ STR Centres-24

➤ Total Breeder seed production (2018-19)=1.17 lakh quintals

➤ Cooperating centres- 63

➤ Total quality seed production (2018-19)= 4.69 lakh quintals

➤ Infrastructure- seed production, processing and storage

Trends in Breeder Seed Production from 1981-82 to 2018-19

1740 lakhs of Quality Planting Materials in the Last 5 years

~14 lakhs of Tissue Culture Raised Seedlings in the Last 5 years



QUANTITY (QUINTAL)

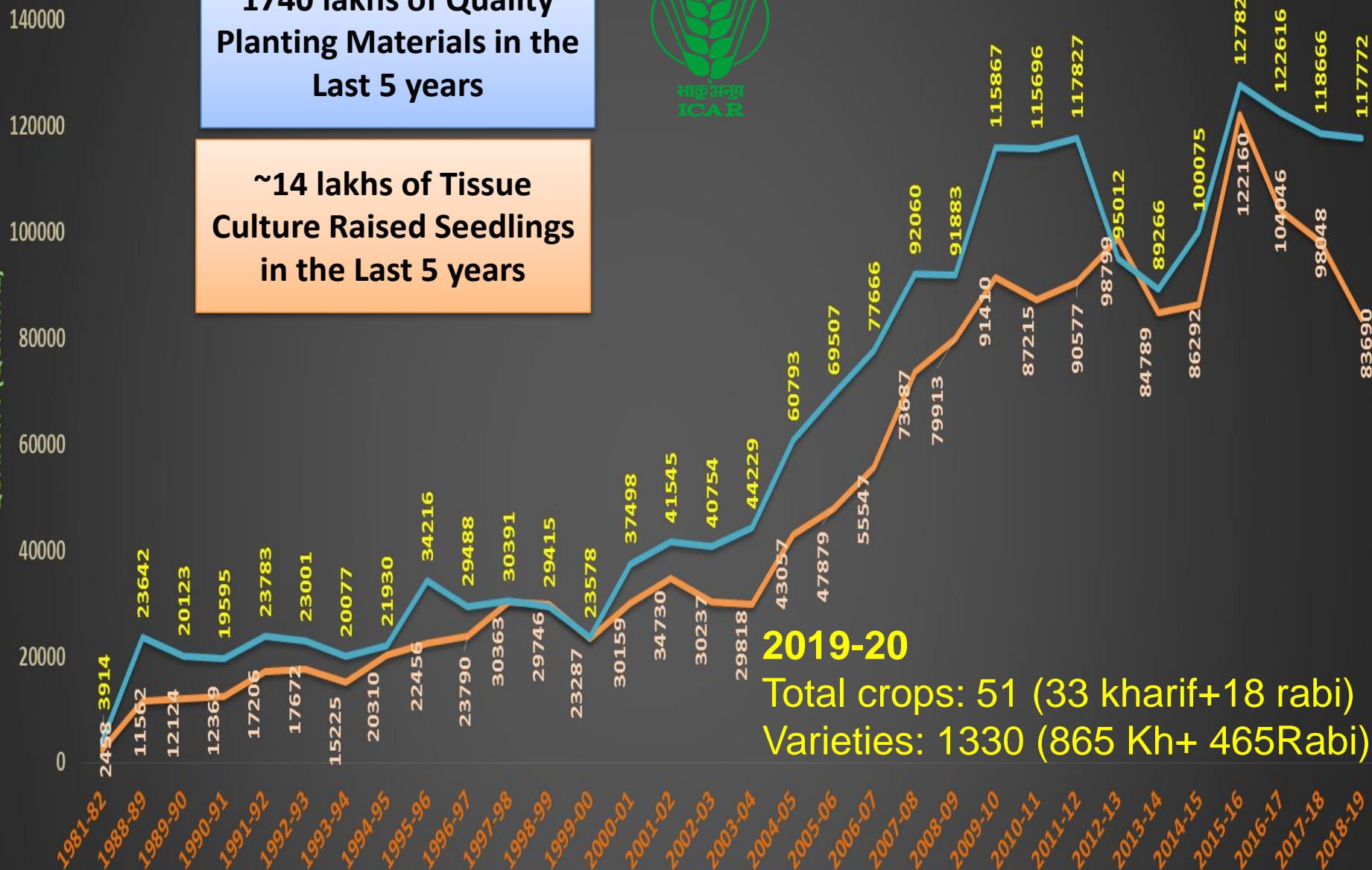
1981-82 1988-89 1989-90 1990-91 1991-92 1992-93 1993-94 1994-95 1995-96 1996-97 1997-98 1998-99 1999-00 2000-01 2001-02 2002-03 2003-04 2004-05 2005-06 2006-07 2007-08 2008-09 2009-10 2010-11 2011-12 2012-13 2013-14 2014-15 2015-16 2016-17 2017-18 2018-19

Indent

Production

2019-20

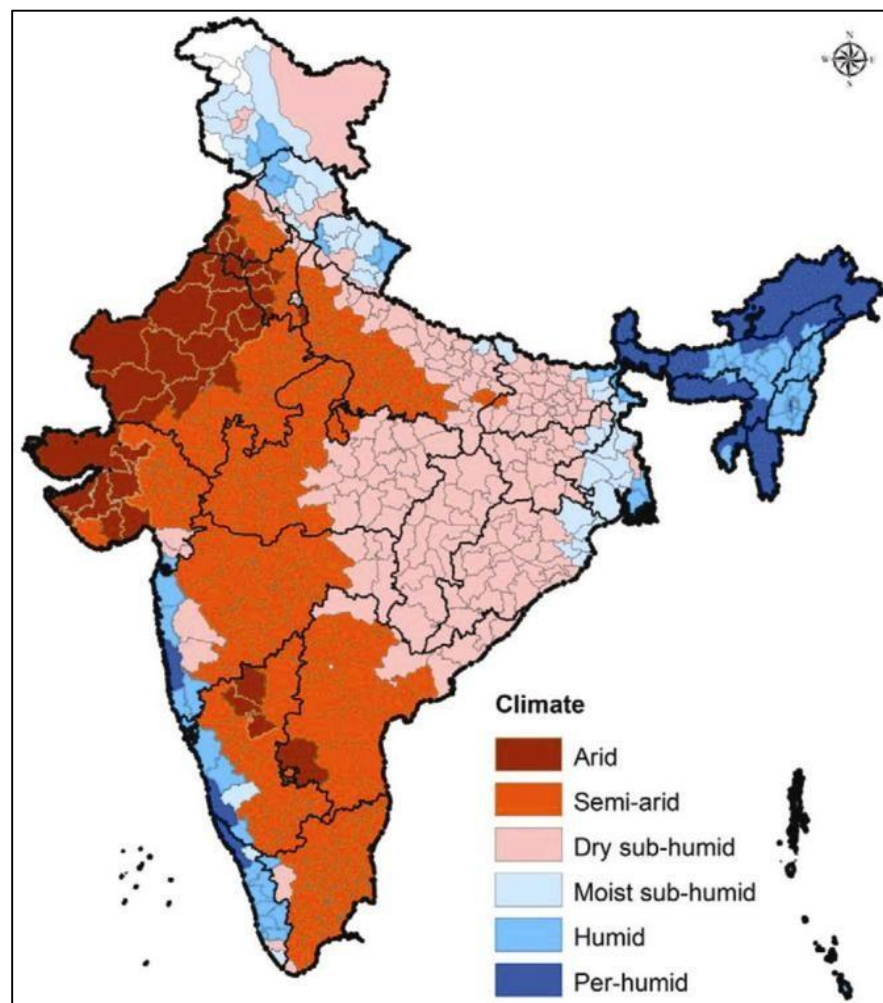
Total crops: 51 (33 kharif+18 rabi)
Varieties: 1330 (865 Kh+ 465Rabi)





Rainfed Agriculture: Key Challenges

- ❖ Managing risks
- ❖ Resource poor operational land resource base
- ❖ Bridging yield gaps
- ❖ Enhancing water productivity
- ❖ Changing cropping patterns
- ❖ Maintaining soil health and productivity
- ❖ Low and skewed farm mechanization

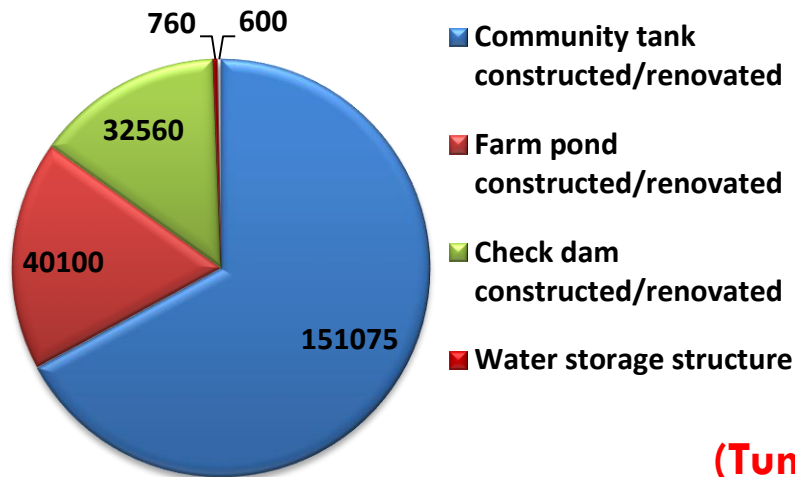


Shift in Climate: 27 % of TGA

Source: Raju et. al. 2013, CRIDA

CRVs can bring in Drought Proofing in even in Regions with 500 mm rainfall

Water Storage Created (Cu m)



172 water harvesting structures created

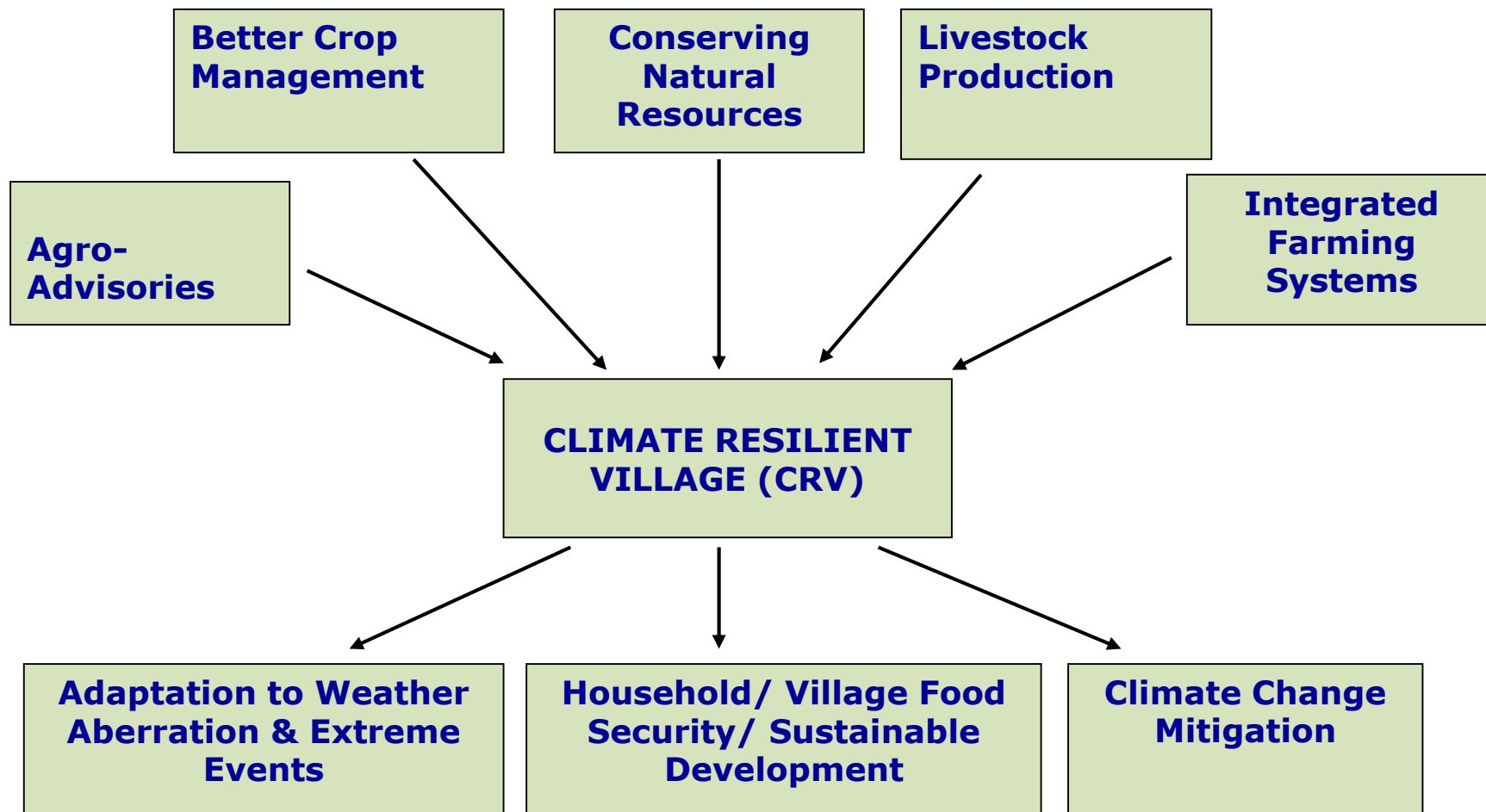
(Tumkuru, Karnataka, India)



- Access to water for critical irrigation was provided to the majority of the households
- **In-situ conservation in uplands** (Trench Cum Bund, Ridge and Furrow, Conservation Furrow)
- Harvested water used for life saving irrigation during the dry spell during July 2015 improved yields in ground nut (40%), paddy (31 %) and finger millet (56%)
- **Area under rabi increased by 21 %**



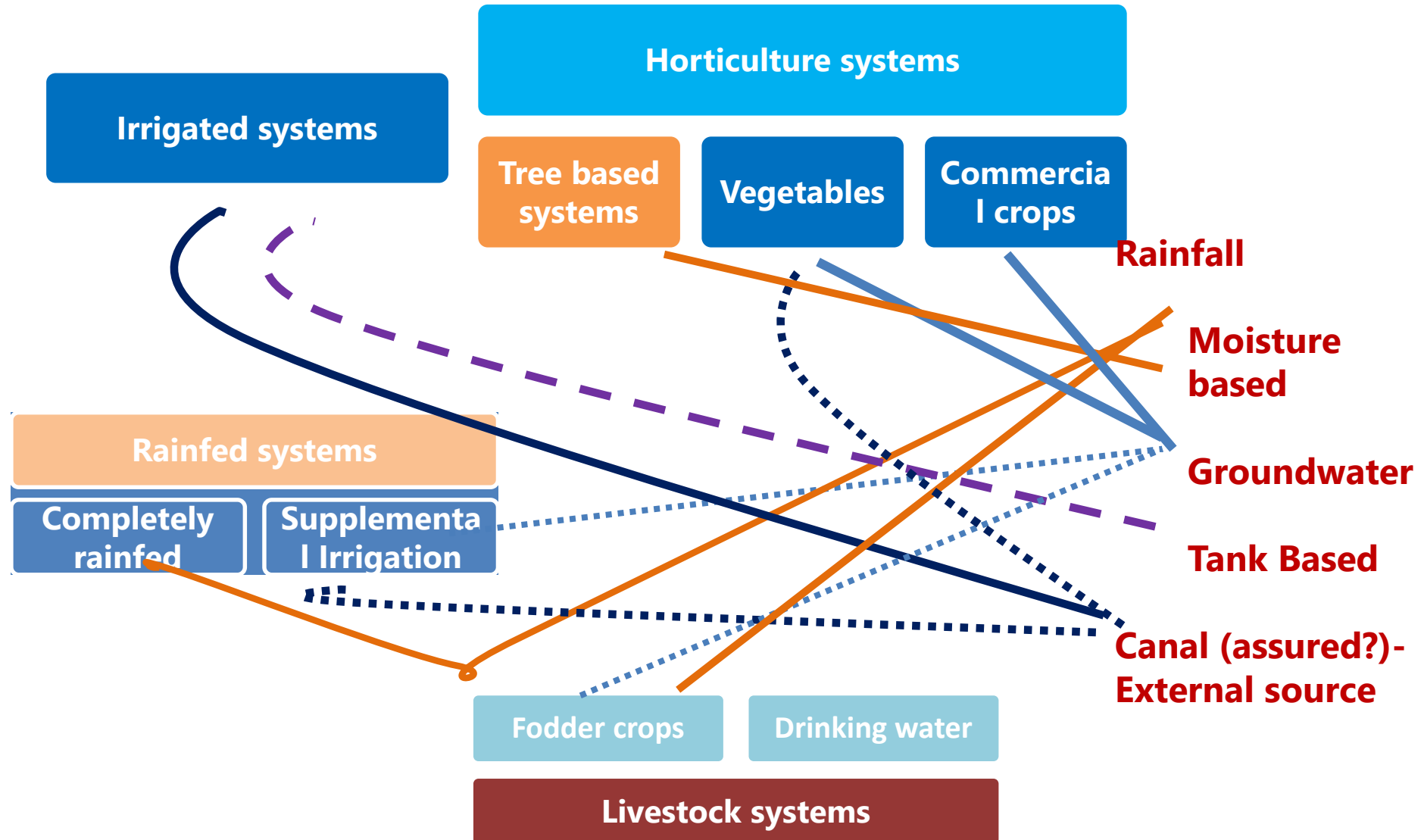
Scaling up Climate Resilient Villages



Systems Linkage in Drought Affected areas: Connecting the Dots

Agricultural Systems

Sources of Water





Water Saving Technologies

- **Laser levelling** helps in saving water and nutrients. It also avoids waterlogging.
- Promote **water saving planting techniques** (timely planting in residual moisture, zero tillage, raised beds)
- Promote **surface mulching**
- Promotion of **micro irrigation techniques**: sprinkler/drip
- Focus on water use efficient genotypes
- Seed priming



Conservation Agriculture for Sustainable Crop Production

Tillage Crop establishment

Conventional



Rotary till



Bed planting



Zero till



Surface residue



Turbo Happy seeder

Need based nitrogen application using NDVI sensor



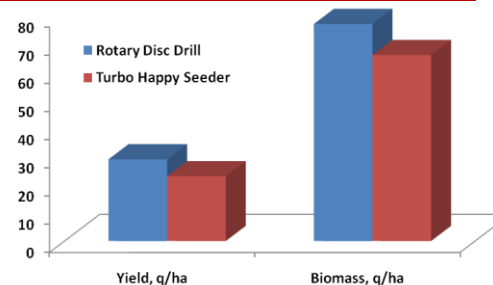
Rotary Disc Drill



RDD sown wheat in SC Ratoon

Using NDVI sensors 15-20% nitrogen can be saved in wheat and rice without any yield penalty. All these technologies put together can increase the profit margins of the farmers by more than 20% along with being environmental friendly.

New Machine for CA: Improved Rotary Disc Drill



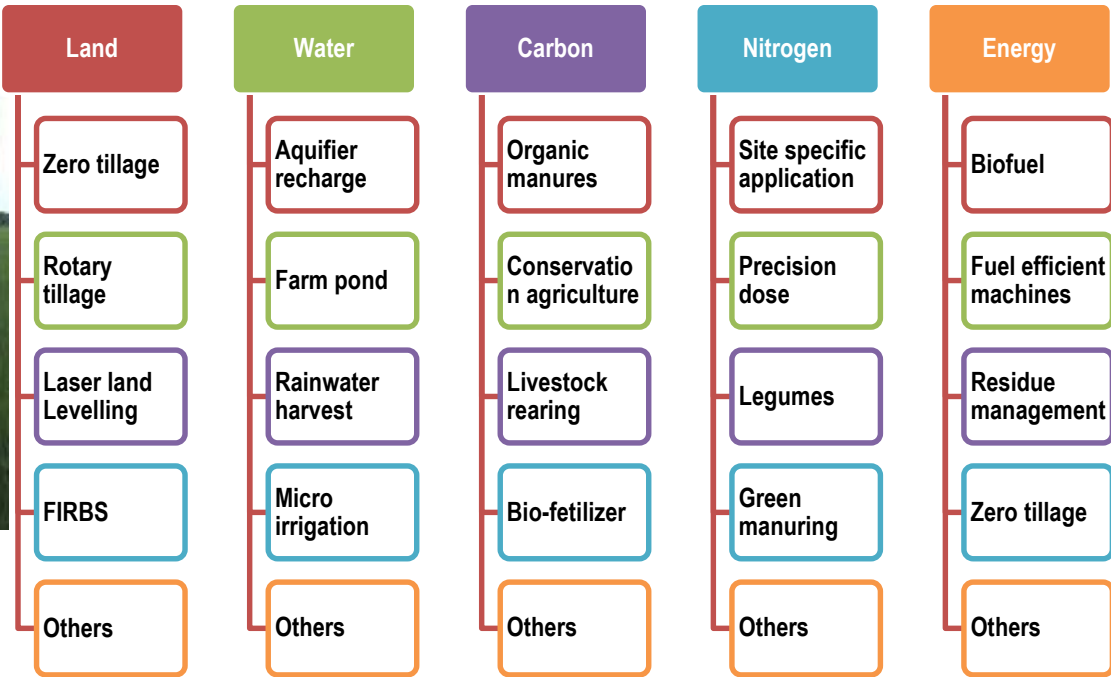
Success Stories (Climate Smart Village & Wheat Village)

Participatory Assessment of Portfolios of Climate Smart Agricultural Practices for Adapting Rice-Wheat Cropping System to Climate Variability in Climate Smart Villages of Haryana

S. No.	Treatment	Stage	Crop Establishment	Precision Land levelling	Fertilizer	Water Management	Plant Protection	Harvest	Yield	Yield Variability
1	Baseline as Usual	FP	FPB-CTB	None	None	None	None	None	None	None
2	Improved with Low intensity	FP	FPB-CTB	None	None	None	None	None	None	None
3	Improved with High intensity	FP	FPB-CTB	None	None	None	None	None	None	None
4	CA with Low intensity	FP	FPB-CTB	Yes	None	None	None	None	None	None
5	CA with medium intensity	FP	FPB-CTB	Yes	None	None	None	None	None	None
6	CA with high intensity	FP	FPB-CTB	Yes	None	None	None	None	None	None

Source: CIMMYT

- Taraori, Karnal
- **Research Focus:** Identify potential donors for IUE



- Wheat varieties sown under CA and CT at Rambha village, Karnal (Haryana)
- Wheat seeding in rice residue using Turbo Happy Seeder and Rotary Disc Drill at farmers' field
- High yielding wheat varieties released for various zones showed similar performance under CA and CT system

District Agriculture Contingency Plans (DACPs)



Online Crop Contingency Planning



Citation

District level contingency plans cover contingency strategies to be taken up by farmers in response to major weather related aberrations such as delay in onset and breaks in monsoon causing early, mid and late season droughts, floods, unusual rains, extreme weather events such as heat wave, cold wave, frost, hailstorm and cyclone. [Read More](#)

State: District: Drought Contingency:

Monsoon Delay:

Farming Situation	Crop	4 Weeks Delay	Varieties
Rainfed red Soils	Maize	Maize	Maize (DHM-109, 115, Prakash)
Rainfed red Soils	Castor	Castor + Pigeonpea (1:1)	Castor : GCH-4, 6, DCH-519 Pigeonpea : Maruthi, Lakshmi, PRG-158
Rainfed red Soils	Pigeonpea	Pigeonpea	Maruthi, PRG-100
Rainfed red Soils	Groundnut	Castor + Pearl millet / Finger millet (1:1)	-
Rainfed red Soils	Sorghum	Pearl millet	ICTP-8203, ICMV-221, HHB-67, RHB-121
Rainfed black soils	Maize	Maize	DHM-109, 115
Rainfed black soils	Pigeonpea	Pigeonpea	LRG-41, MRG-66
Rainfed black soils	Cotton	Cotton	LRA-5166, LK-861
Rainfed black soils	Sunflower	Sunflower	KBSH-44, Morden, DRSF-108
Rainfed black soils	Finger millet	Finger millet	Maruthi, Suraj, Champavathi

- DACPs available for 650 districts
- Plans for delay in monsoon and early, mid-season and terminal droughts
- Implemented through State Govt with technical backstopping by Indian Council of Agricultural Research (ICAR) and State Agricultural Universities (SAUs)
- Saving on input cost, time of spraying, irrigation scheduling and crop harvesting
- Effectively used to cope with droughts and other climatic risks

<http://www.crida.in:82/contingencyplanning/>

EcoDRR (Ecosystem based Drought Risk Reduction)

Points to Ponder

❖ If available rainfall is **more than** the systems requirement

Management of **available resource** is the main option

❖ If available resource is **less than** the systems requirement

Management of **all resources** becomes important

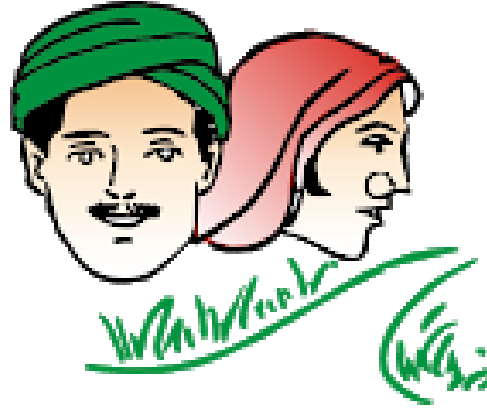
Need to consider

- ✓ Agroecosystem perspective - Climate, soils, biodiversity,, production systems
- ✓ Priority for systems – Resilient farming systems (crop, animal, tree based for climate adaptation
- ✓ Enhancing soil quality, water productivity and energy use efficiency, Biodiversity and crop improvement
- ✓ Governance issues
- ✓ Participatory management



Areas of collaborations

- Exchange of plant genetic resources
- Sharing suitable varietal technologies
- Seed production systems
- Collaborations in research
- Scaling up of Climate Resilient Village Models
- Precision irrigation technology
- Human resource development (Scientists and students)



हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrsearch with a human touch

Thanks

