हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद
Agrisearch with a human touch

Adaptation of Agriculture to Climate Change Mitigation

Ch. Srinivasa Rao
Director

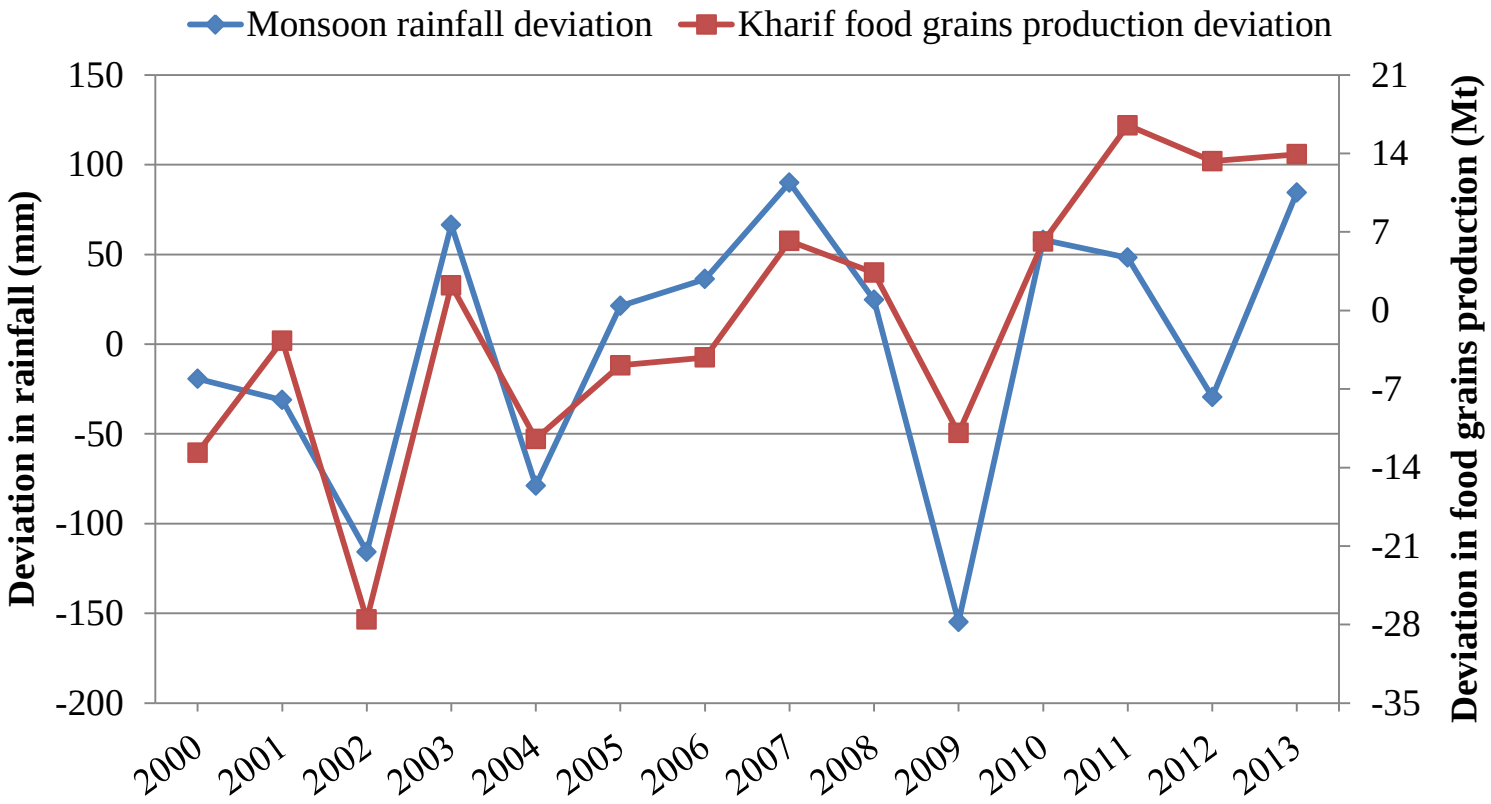
ICAR-Central Research Institute for Dryland Agriculture
Hyderabad

NICRA
National Initiative on Climate Resilient Agriculture

Weather Aberrations in India

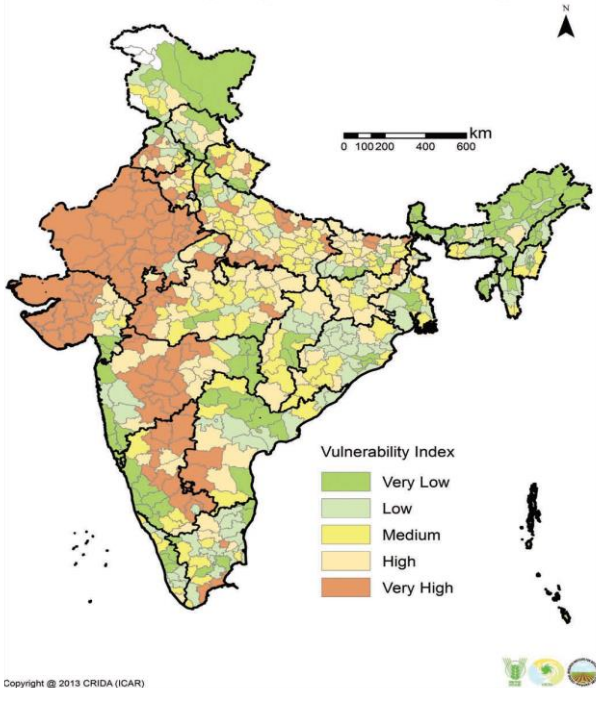
- Increasing attention **on climate change impacts and vulnerability in the agricultural sector**
- **India is no exception** of experiencing such weather aberrations with high impacts
- A stronger focus on **adapting agriculture to current and future climate change**
- For this, simultaneous **short term and long term strategies** are needed
- **Short term responses - Real time contingencies** to cope with seasonal weather aberrations for higher farm productivity, food security at household level
- **Long-term strategies – for mitigation of climate change** besides having farm level impacts

Monsoon rainfall vs. deviation in food grain production during *kharif* (rainy season)

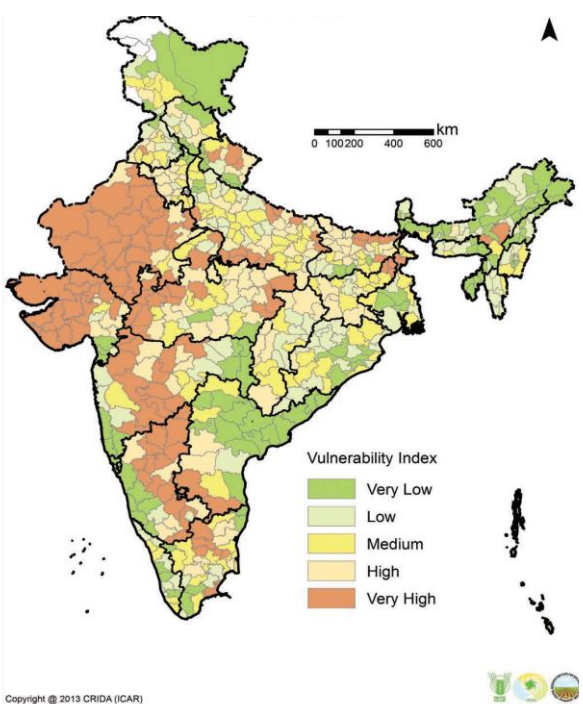


Agricultural production in India is closely linked to the performance of summer monsoon (June to September) which contributes about 75% of the annual precipitation

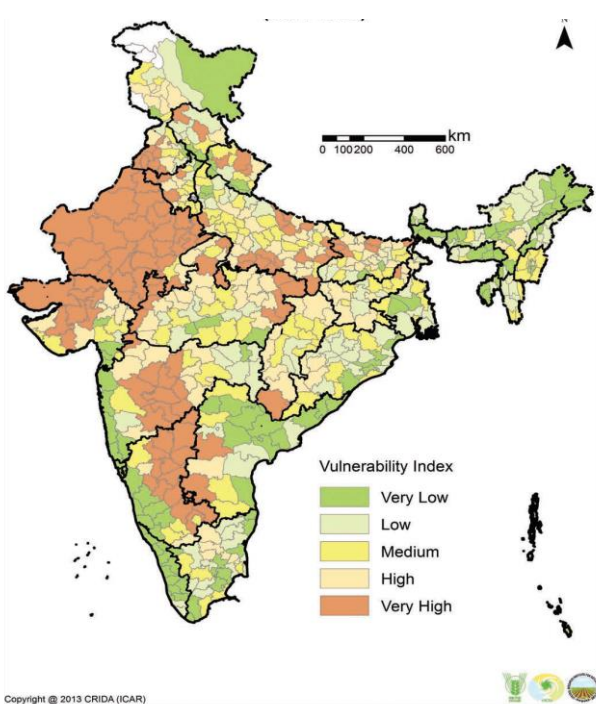
District-level vulnerability of Indian agriculture to climate change



Present



Mid-century (2021-2050)



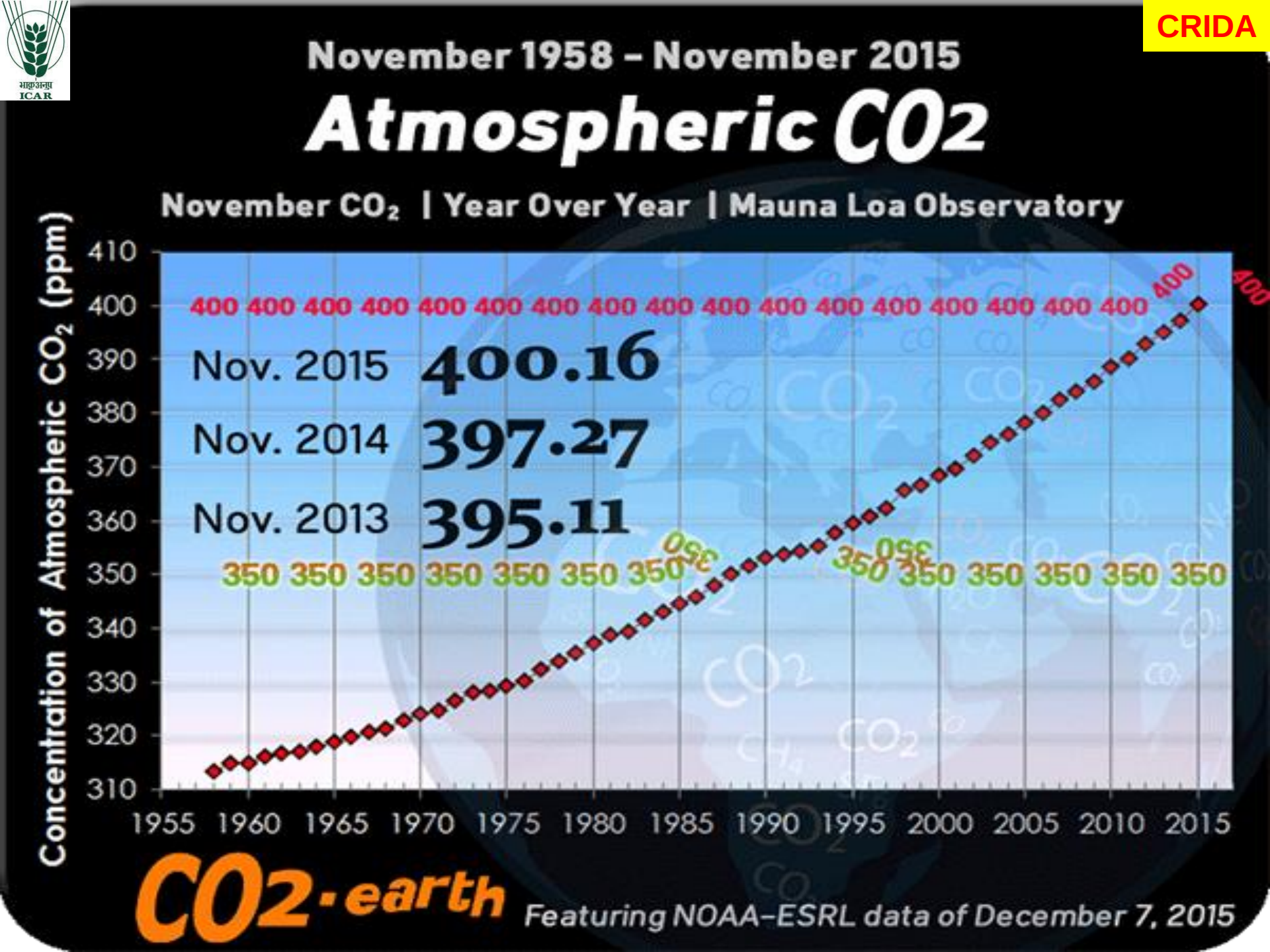
End of the century (2071-2098)

Most districts along the eastern and western coast, north-eastern states are less vulnerable

By mid-century (2021-2050), districts in Rajasthan, Gujarat, Madhya Pradesh, Karnataka, Maharashtra, Andhra Pradesh, Tamil Nadu, eastern Uttar Pradesh and Bihar exhibit very high and high vulnerability.

Towards end of the century (2071-2098), almost all districts in Rajasthan and many districts in Gujarat, Maharashtra, Karnataka exhibit very high vulnerability.

CRIDA


November 1958 – November 2015
Atmospheric CO2
November CO2 | Year Over Year | Mauna Loa Observatory
Concentration of Atmospheric CO2 (ppm)
410
400
390
380
370
360
350
340
330
320
310
400 400 400 400 400 400 400 400 400 400 400 400 400 400 400 400 400 400
Nov. 2015 400.16
Nov. 2014 397.27
Nov. 2013 395.11
350 350 350 350 350 350 350 350 350 350 350 350 350 350 350 350 350
1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015
CO2·earth
Featuring NOAA-ESRL data of December 7, 2015

Food demand projections of different studies for India

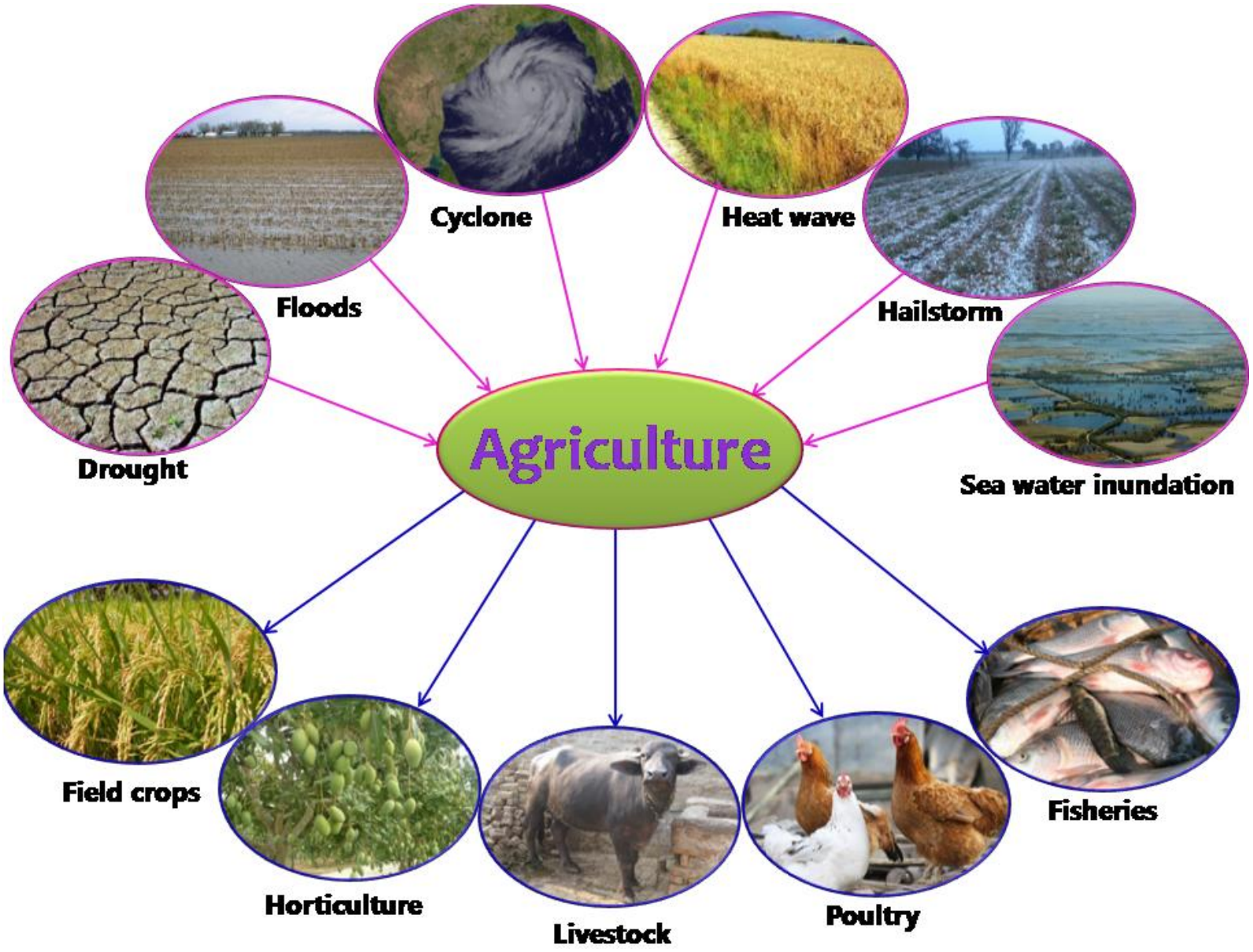
Source of study	Year	Rice	Wheat	Total cereals	Pulses	Food grains
Bansil (1996)	2020	-	-	-	-	241.4
Kumar (1998)	2020	134.0	127.3	309.0	-	-
Paroda and Kumar (2000)	2020	111.9	79.9	229.0	23.8	252.8
Radhakrishna and Reddy (2004)	2020	118.9	92.4	221.1	19.5	240.6
Mittal (2008)	2021	96.8	64.3	245.1	42.5	287.6
	2026	102.1	65.9	277.2	57.7	334.9
Kumar et al (2009)	2021-22	113.3	89.5	233.6	19.5	253.2
Amarasinghe and Singh (2009)	2025	109	91	273	18	291.0
	2050	117	102	356	21	377.0
Singh (2013)	2020	106.7	85.7	220.0	23.2	243.2

Projected changes in crop yields (%) at maximum changes in temperature and rainfall by 2035, 2065 and 2100

Crop	2035	2065	2100
Rainy season			
Rice	-7.1	-11.5	-15.4
Maize	-1.2	-3.7	-4.2
Sorghum	-3.3	-5.3	-7.1
Pigeonpea	-10.1	-17.7	-23.3
Groundnut	-5.6	-8.6	-11.8
Winter season			
Wheat	-8.3	-15.4	-22.0
Barley	-2.5	-4.7	-6.8
Chickpea	-10.0	-18.6	-26.2
Rapeseed-mustard	0.3	0.7	0.5

Maximum changes in temperature and rainfall are 1.3°& 7% by 2035, 2.5°& 26% by 2065 and 3.5°& 27% by 2100, respectively (Source: Adapted from Birthal et al., 2014)

Weather aberrations and affected agriculture sector



India

1.3 Billion + Indians

Marginal Lands

Declining Per Capita Land Availability

Socio-economic structure

Markets & Price

India Food Security

Climate Variability

Productivity vs Food Security

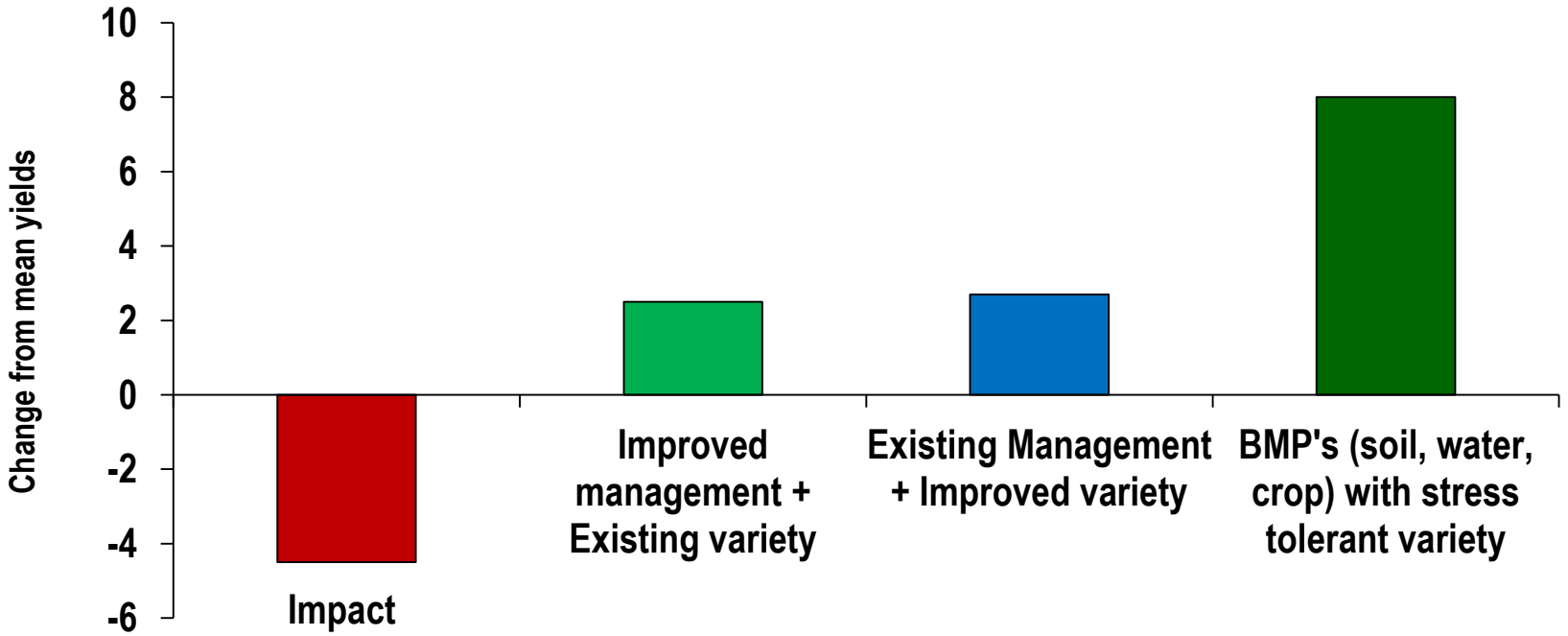
Climate Change

@ Droughts
@ Cyclones/Floods
@ Heat wave
@ Hail storms
@ Frost

* 270 million tons +
* Imports of food legumes and edible oils

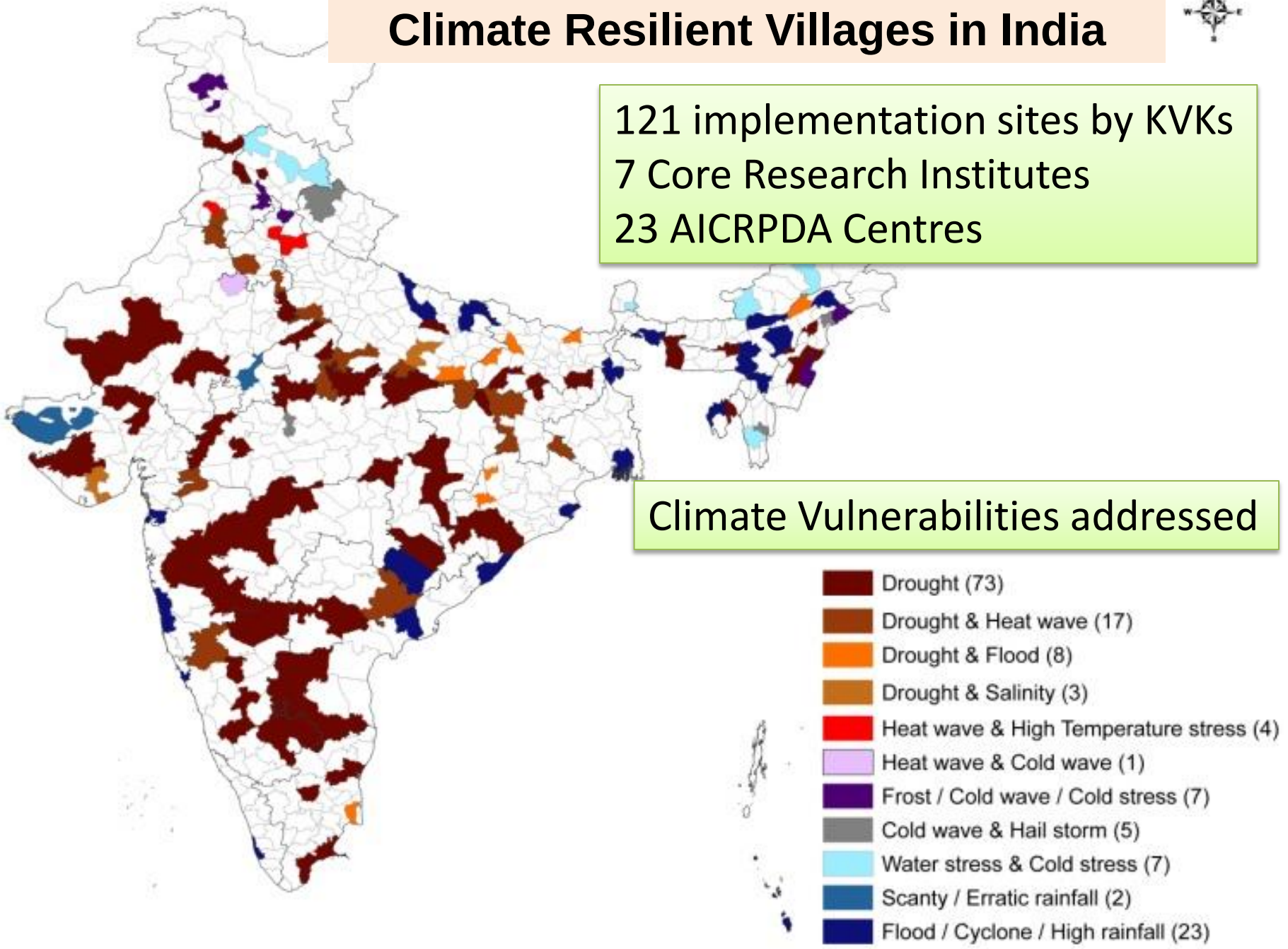
Hunger
Malnutrition

Integrated Genetic Natural Resource Management (IGNRM): Key Adaptation Strategy for Weather Aberrations

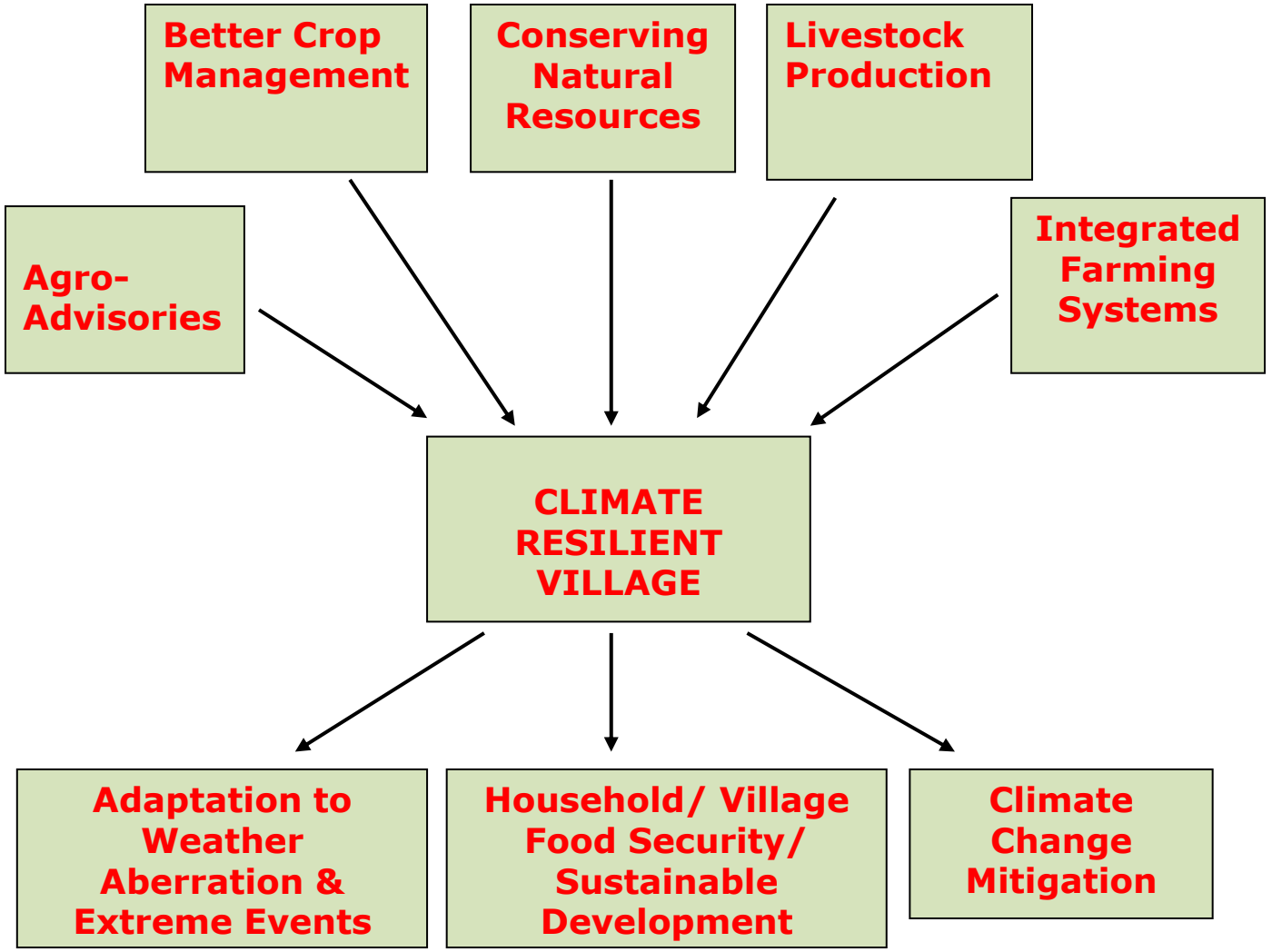


Climate Resilient Villages in India

121 implementation sites by KVKs
7 Core Research Institutes
23 AICRPDA Centres

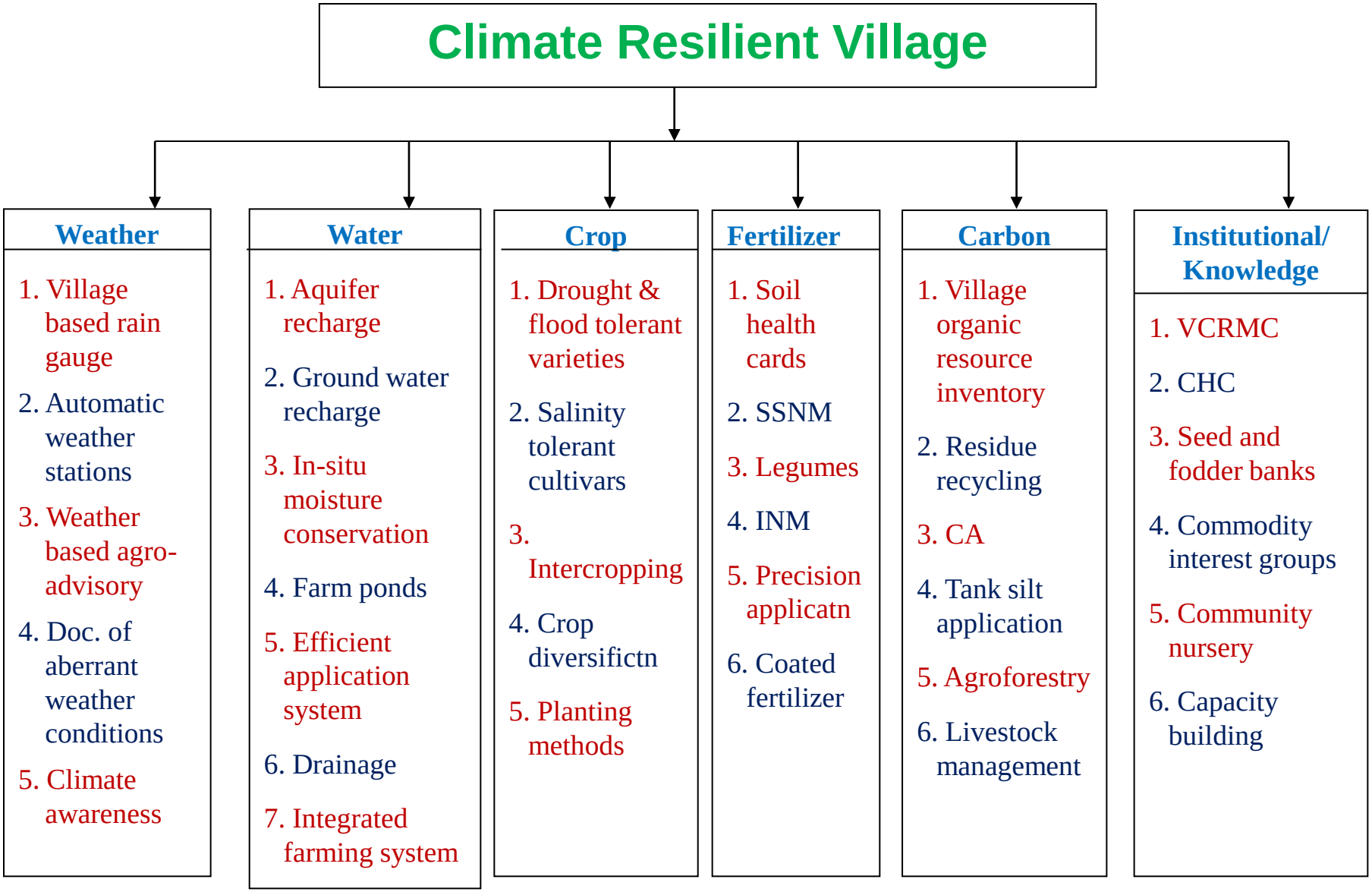


Conceptual outlay of CRVs



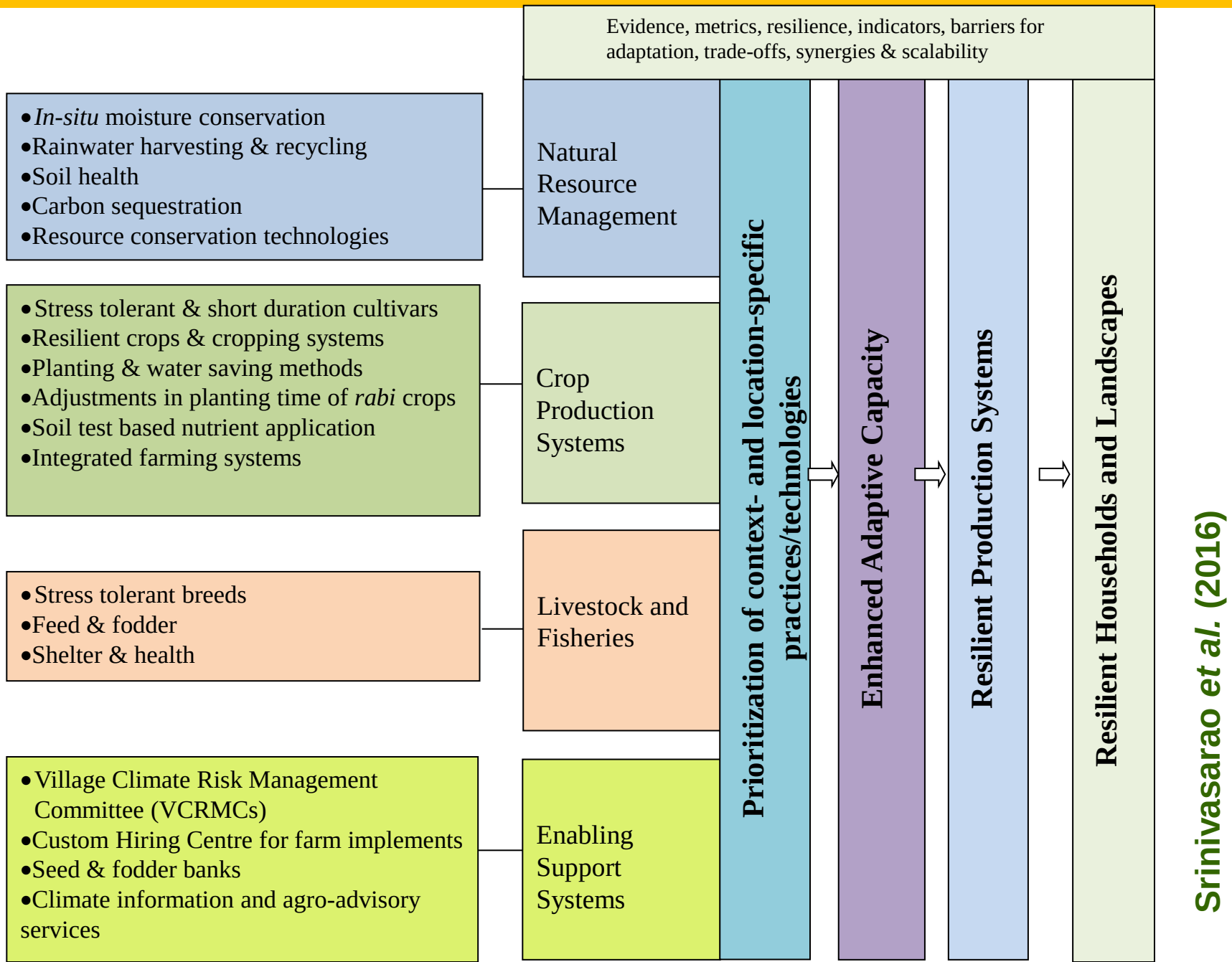
Srinivasarao *et al.* (2016)

Components and technology framework of CRVs

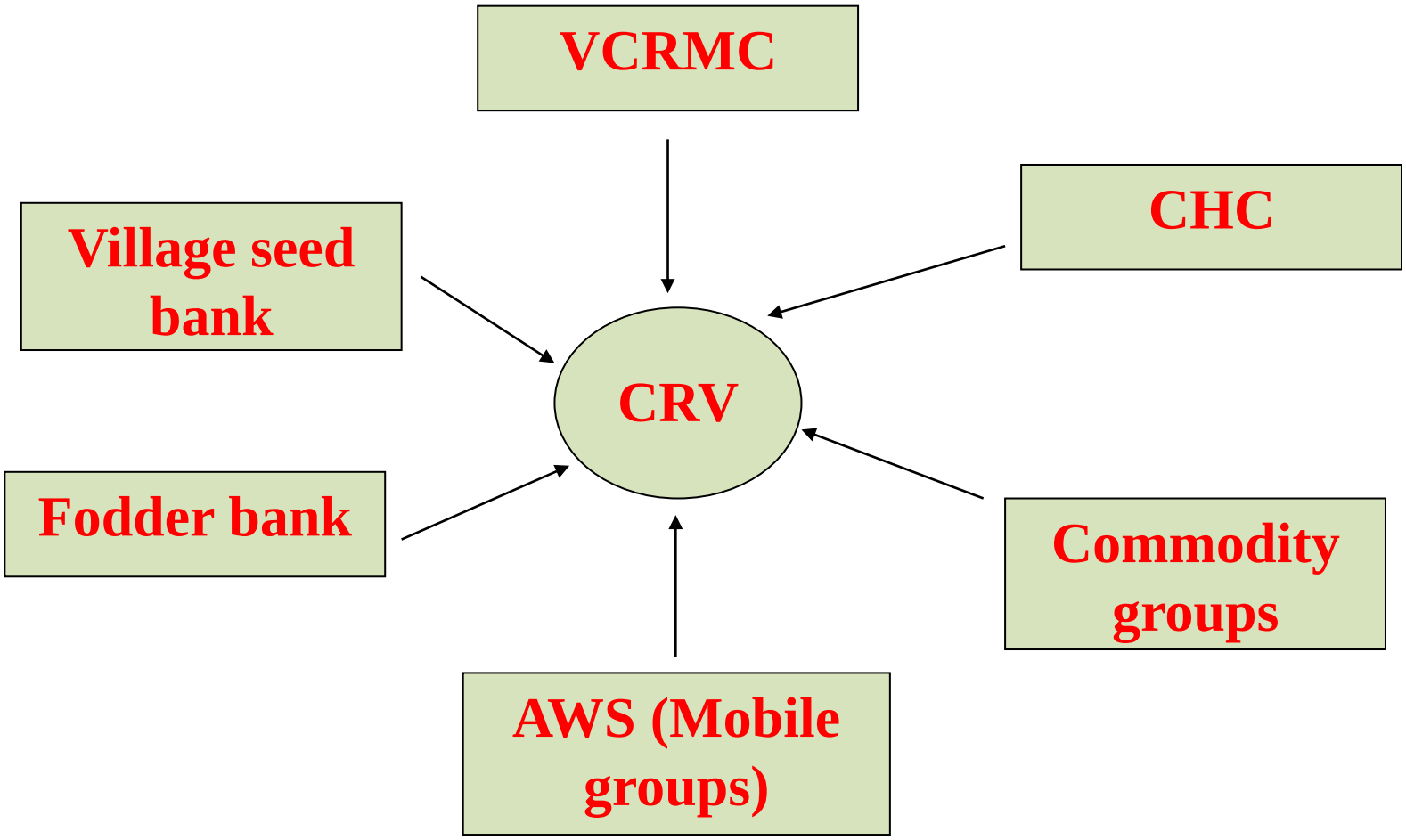


Srinivasarao *et al.* (2016)

Framework for developing climate resilient villages



Village level institutional setup in CRVs



Srinivasarao *et al.* (2016)

Delayed onset of Monsoon

Challenge is to sow and establish a crop

Major options

- **Alternate crops**
- **Short duration varieties**

Beyond the sowing window, choice of alternate crops or cultivars depends on the farming situation, soil, rainfall and cropping pattern in the location and extent of delay in the onset of monsoon.

Delayed onset of Monsoon: Prefer Resilient Crops & Varieties

Centre (State)	Delay in onset by	Crop	Variety
Chianki (Jharkhand)	21 days	Rice Sesame	IR 92521-7-5 Shekhar
Rewa (Madhya Pradesh)	10 days	Soybean Pigeonpea	JS 20-29 Asha
SK Nagar (Gujarat)	31 days	Pearlmillet Clusterbean	GHB 558 GG2
Vijayapura (Karnataka)	28 days	Pearlmillet	ICTP- 8203 (ICMV-211)

Rice var. IR 92521-7-5

Sesame var. Shekhar

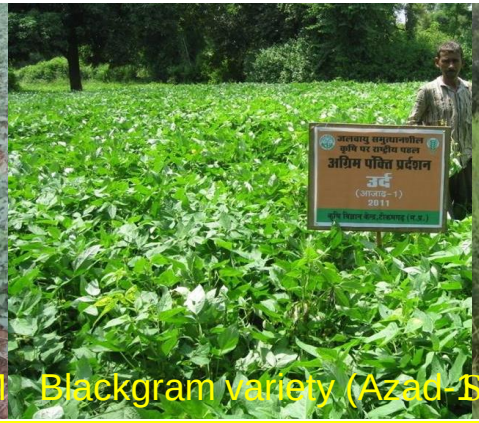
Pearlmillet var. ICTP- 8203 (ICMV-211)

Short duration drought tolerant crop varieties suitable for late sowings

Crop	Varieties	Avg. Yield (q/ha) (Demo)	Avg. Yield (q/ha) (FP)
Blackgram	PU-35, Shekhar, Pusa Vishal, CO-6, Samrat, Azad Urd-1	8.82	6.32
Greengram	PDM-139, VBN-3, BM-2003-2, Pratap	9.12	7.28
Groundnut	TG 37A, TG 38, ICGV-91114, JGN-23	11.77	9.91
Pigeonpea	TJT-501, ICPL-88039, BRG-2, BRG-4,	11.50	8.63


Groundnut variety (GG-5)


Green gram variety (TARM



Blackgram variety (Azad-


Short duration pigeopea (BRG 2)

Scope for scaling up: MP, Jharkhand, UP, TN, Gujarat, Karnataka, Bihar,

Community paddy nursery as a contingency measure for delayed planting

Bihar & Jharkhand

Staggered community nursery raised under assured irrigation at an interval of 2 weeks

- ✓ First nursery raised by 15th June with long duration variety (>140 days) to transplant 3-4 weeks old seedlings by first fortnight of July
- ✓ If delay / deficit conditions prevail for 4 weeks, second nursery is raised with medium duration varieties (125-135 days) by 1st July to transplant in the 3rd 4th week of July

Direct Seeded Rice for delayed planting & promoting water use efficiency

Technology	Input cost (Rs/ha)	Av. Yield (q/ha)	BC Ratio
Direct Seeding Seed @ 30 kg/ha	14100/-	45.0	2.19
Conventional method (60-80 kg/ha)	18900/-	47.0	1.85

- Timely sowing
- Water saving (25%)
- Diesel saving for pumping (27%)
- Labor saving (35-40 mandays)
- Early maturity (7-10 days) for timely *rabi* cropping
- Low methane emissions / less GWP
- Enhances system productivity

Scope for upscaling

North-west IGP, Bihar, Jharkhand, Odisha, AP, Chattisgarh

Adoption of Resilient Intercropping Systems

Problem :Low productivity and income of crops due to erratic rainfall

Crop	KVK	FP (q/ha)	IP (q/ha)	Yield advantage (%)
Groundnut + Pigeonpea (4:1)	Gumla	15.2	16.7	9.9
Maize + Pigeonpea (6:2)	Davanagere	44.5	54.5	22
Soybean + Pigeonpea (6:2)	Amravati	18.0	21.5	64
Soybean + Pigeonpea (4:2)	Aurangabad	12.0	16.0	33
Cotton+Greengram (1:1)	Aurangabad	15.5	19.4	25
Cotton+Blackgram (1:1)	Aurangabad	15.5	17.7	14
Sateria+Pigeonpea (5:1)	Kurnool	21.0	24.4	16

Cotton + Greengram (1:1)

Soybean + Pigeonpea (4:2)

Cotton + pigeonpea (6:2)

Cotton + blackgram (1:1)

In situ moisture conservation is the key intervention to mitigate early season drought

In deep black soils of Vidarbha and Marathwada, Maharashtra, opening conservation furrow at 35 DAS of soybean and cotton , enhances yield upto 21%

In black soils of North Gujarath ,with ridge and furrow system, the **RWUE (kg/ha-mm) and bean yield in castor was 1.55 and 13.8 q/ha as compared to flatbed system (1.13 &8.6 q/ha, respectively)**

In medium deep black soils of Chhattisgarh, with furrow opening in upland rice at 25 days after sowing, the **crop yield was 22.3 q/ha compared to 18.5 q/ha in farmers' practice**

Midseason/ Terminal drought : Foliar Sprays

AICRPDA Centre	Crop	Treatment	Yield (kg/ha)	Net returns (Rs/ha)	RWUE (kg/ha -mm)
SK Nagar **Soils: Sandy/sandy loam)** **(RF Deficit 83 % in Aug & 74 % in Sep)**	**Pearlmillet**	Thiourea @ 1000 ppm Urea at 1%	530 475	4387 3408	0.61 0.48
Indore **(Deep black)** **(RF Deficit 45% in Sep)**	**Soybean**	Thiourea @ 1% KCl @ 2% KNO_3 @ 1%	333 306 327	- - -	0.66 0.61 0.65
Parbhani **(Deep black)** **(RF Deficit 36 % in Aug)**	**Maize**	KNO_3 @ 2% Kaoline @ 7%	582 544	8534 7028	1.65 1.53
Arjia **(Medium deep black)** **(RF Deficit 36% in Aug & 80% in Sep)**	**Maize**	Thiourea @ 0.5%	1851	-	-

Midseason/terminal drought : Supplemental irrigation/Foliar spray

NICRA Village (District/State)	Dry spells	Intervention	Yield (kg/ha)	Net income (Rs/ha)
Chianki (Lakhimpur/ Assam) (Loamy soil)	23 days (17 Dec -9 Jan)	**Supplemental irrigation (tuber formation)** in potato	16970 (88%)	96425
Terha Saraya (Mirzapur / Uttar Pradesh) (Loamy soils)	31 days (19 Aug – 21 Sep) and 34 days (23 Sep – 27 Oct)	**Supplemental irrigatio (panicle initiation)** in rice	2450 (Rainfed crop failed)	18800
Kochariya (Bhilwara/ Rajasthan) (Medium deep black)	12 days (30 July to 10 Aug) and 40 days (15 Aug till harvest)	**Supplemental irrigation at silking/floweing stage** in maize + blackgram intercropping (2:2)	1330 (52%)	34,134
Babulgaon (Parbhani/ Maharashtra)	43 days (19 Sep -31 Oct)	**Foliar spray of KNO_3 @ 2%** in cotton	804 (13%)	11168

Zero till wheat to cope with terminal heat stress

Crop		Wheat
Technology demonstrated		Sowing with zero tillage
Yield q/ha	Demo	40.45
	Farmers Practice	32.87
% yield increase		23
B:C ratio		2.71 (1.67)

Impact:

- Saves irrigation water up to 10-15% during 1st irrigation
- Early sowing in late condition
- Uniform seed germination
- 25% less seed rate (save 2 ploughings)
- Low weed population
- Increased grain yield by 23% with 2.71 B:C ratio

Broad bed furrow protects soybean during excess rainfall in Madhya Pradesh

Particular	Broad bed and Furrow	Farmers Practice	% Increase
Grain Yield (kg/ha)	1937	1152	40.5
Net Return (Rs/ha)	38805	18898	51.3
B:C Ratio	3.51	2.41	
Rain Water Use Efficiency (kg/ha-mm)	2.09	1.24	

Making of BBFs

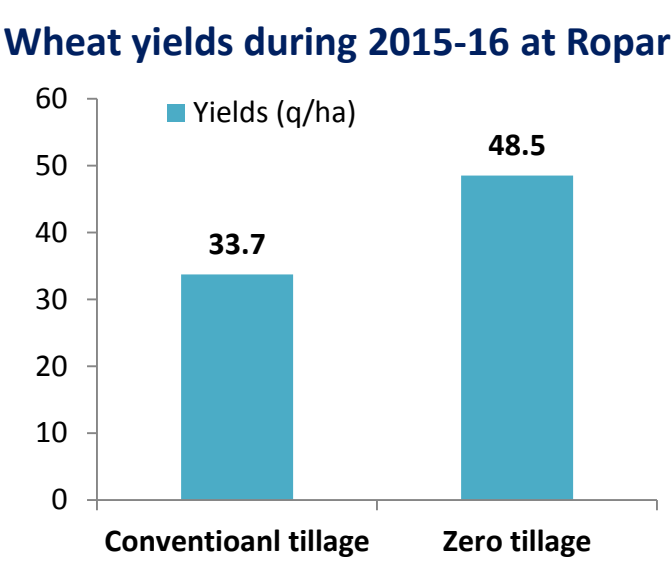
Drainage in furrows

Crop stand in BBF

Zero tillage minimizes the yield loss due to intense rains

Crop lodging in conventional tillage

Crop in zero till sown wheat

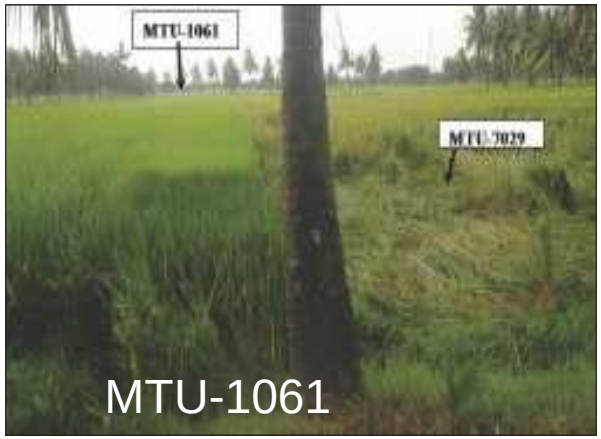


- Zero till (ZT) sowing minimizes losses due to lodging of wheat.
- ZT gave higher yields by 14 q/ha over conventional tillage
- Higher returns by up to Rs.21,000/ha
- Severe loss (in about 20% of area) in wheat yields because of lodging due to unseasonal rains in March 2016
- Adoption of ZT would have reduced the loss and increased the production by one million tonne in Punjab (Rs.1525 crores)

Adoption of Flood Tolerant Paddy varieties in Flood prone areas

- Identified performing varieties in low, medium and high inundation areas
- Submergence tolerance for 7-10 days
- Increased yield due to reduced lodging
- Prevented loss in grain and straw yield

Tolerant paddy cultivars	Yield (q/ha)		% increase in yield	B: C ratio
	Demo	Local		
Swarna Sub-1	41.25	33.75	18.9	2.09
MTU-1061	45.28	28.1	23.1	1.84
MTU-1140	55.1	31.8	73.2	2.01
Jalashree	30.4	27.0	12.5	1.7
Karjat-6	38.0	31.6	20.2	1.3
RGL-2537	53.9	45.0	19.8	1.8



Scope for scaling up : Assam, AP, Odisha, West Bengal, MH

Performance of flood tolerant varieties of paddy

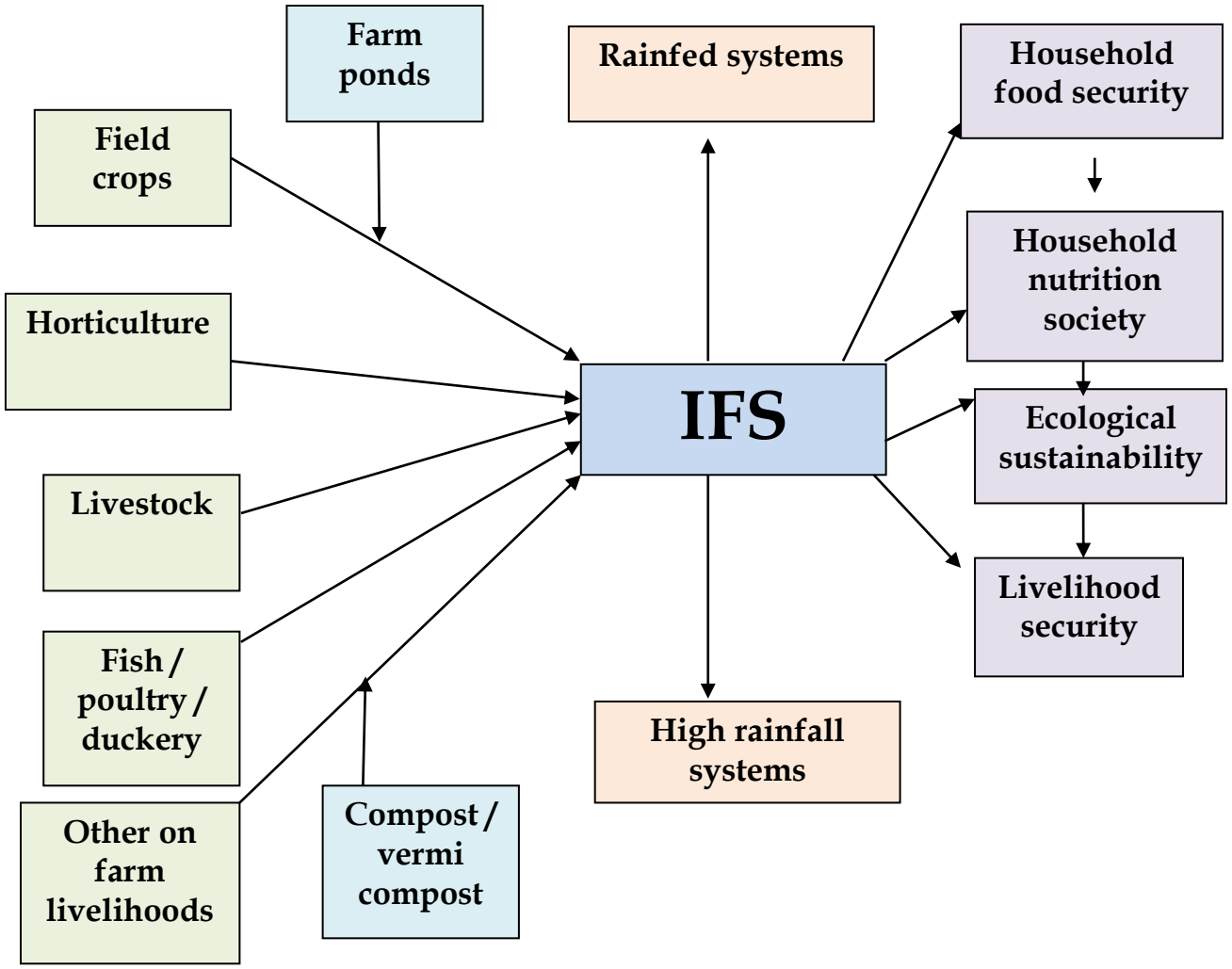
Flooding and submergence	Variety	Location	No. of farmers	Increase in yield over FP (%)
Water level <1 m and submergence <10 days	Swarna sub-1, Dishang, Joymoti, MTU-1010, MTU-1100, MTU-1064, MTU-1140, MTU-7029, BPT-5204, Dehangi, Gitesh, Shasharang	Kushinagar, Saran, Gorakhpur, Maharajgunj, Baharaich, Gonda, West Godavari, Srikakulam, Kendrapara, Jharsuguda, Buxar, Jehanabad, Villururam	1071	30-35
Water level >1 m and submergence >10 days	Jalashree, Jalkuwari, Rajashree, Karjat-2, Karjat-6, GAR-13, Lalat, Luit	Dhubri, Cachar, Sonitpur, Dibrugarh, Kushinagar, Kendrapara	208	20-25

Srinivasarao *et al.* (2016)

Improved breeds introduced in different villages

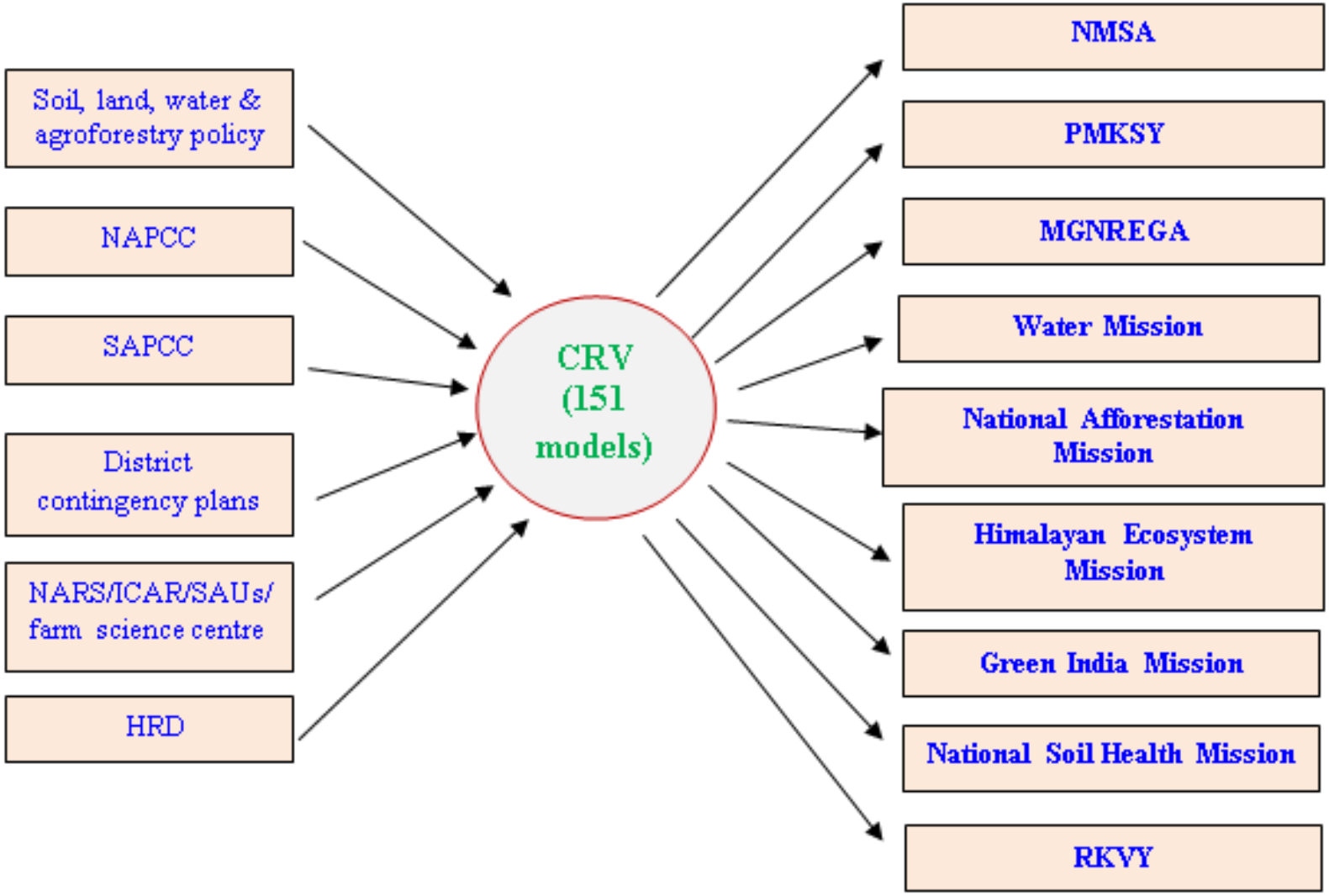
District	Improved breed	No. of animals/ birds
Cachar, Dibrugarh	Kalinga Brown (poultry), Vanjara (poultry)	1000
Dimapur	Vanaraja and Gramapriya (poultry)	200
East Sikkim	Vanaraja (poultry)	140
Lunglei	Vanaraja (poultry)	10
Anantapur	Rajasree (poultry)	35
Khammam, Nalgonda	Vanajara (poultry)	30
Balaghat	Kadaknath (poultry)	100
Kendrapara, Sonitpur	Vanaraja and Blackrock (poultry)	1215
Ganjam	Rainbow Rooster (poultry)	100
Jhansi	Chabro (poultry)	400
Ri-Bhoi	Vanaraja (poultry), Assam hill goat and Hampshire cross (pig)	48
Senapati	Gramapriya (poultry) and Hampshire cross (pig)	300
West Kameng	Ghungroo, Hampshire cross, Duric,	17
Gumla, Chatra	Beetal buck (goat)	21
Coochbehar	Khaki campbel (duck), Vanjara (poultry)	46
Chitrakoot	Latitpuri (goat)	52
Gorakhpur	Barbary (goat)	5
Ahmednagar, Aurangabad	Sirohi (goat), Girija (poultry)	60
Datia, Satna	Murrah (buffalo), Jamunapari & Latitpuri (goat)	30
Tikamgarh	Jamunapari (goat)	5
Jharsuguda	Black Bengal (goat)	40
Namakkal	Rams of NARI Swarna (sheep), Telicherry (goat)	2
Jodhpur	Tharparkar (bullock)	82

Integrated Farming Systems (IFS) models for household food, livelihood and ecological sustainability



Srinivasarao *et al.* (2016)

Expansion strategy of climate resilient villages in India



Srinivasarao *et al.* (2016)

Dissemination of district plans

Contingency Preparedness-Stakeholders to Cope Deficient Rainfall-2015

@ CRIDA-Central Level
@ Maharashtra
@ MP
@ Karnataka
@ Andhra Pradesh
@ Telangana
@ Chhattisgarh
@ Rajasthan
@ Gujarat
@ Jharkhand
@ Uttar Pradesh
@ Haryana

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 rain... heat wave, cold wave, frost, hailstorm and cyclone. Read More

Monsoon delay

State : Karnataka | District : Bangalore-Rural | Drought Contingency : Monsoon Delay

Monsoon Delay: 6 Weeks Delay

Farming Situation	Crop	6 Weeks Delay	Varieties
Shallow red soils	Finger millet	Finger millet / Little millet / Foxtail millet	Finger millet: GPU-28 Little millet: CO-2, PRC-3 Foxtail millet: RS-118, K-221-1
Shallow red soils	Maize	Maize/ Blackgram/ Greengram/ Fieldbean	Maize : DHM- 2, Ganga-11, Deccan-103 Fieldbean: HA-3, 4
Shallow red soils	Groundnut	Groundnut	Groundn...
Shallow red soils	Pigeonpea	Pigeonpea	Pigeonpe...

www.crida.in:82/contingency planning/

CRIDA

623-District Agriculture Contingency Plans

Updating of contingency plans with Universities/KVKs

NICRA/CRIDA/ AICRPDA Research outputs & Agri. Universities/KVKs

NMSA

Implementation of DCPs

District (with State Government authorities)

Taluq/Mandal (AICRPDA/AICRPAM network)

Villages (through KVKs under NICRA-TDC

@ Able to reach State Action Plans - NMSA
@ District-Mandal-Village Level Implementati
@ 2014: 9% Sowing area reduction offset
@ Large scale land treatments implemented
@ 2015: 12 State Interface Meetings
@ 2016: 11 State Interface Meetings

The District Contingency Plans cover

- Delay in monsoon onset
- Breaks in monsoon leading to early, mid and late-season droughts
- Delayed or limited release of water for irrigation
- Floods, Unseasonal rains
- Extreme weather events: Heat wave, Cold wave, Frost, Hailstorm, Cyclone

- Major farming situation-wise &
- Cropping system-wise

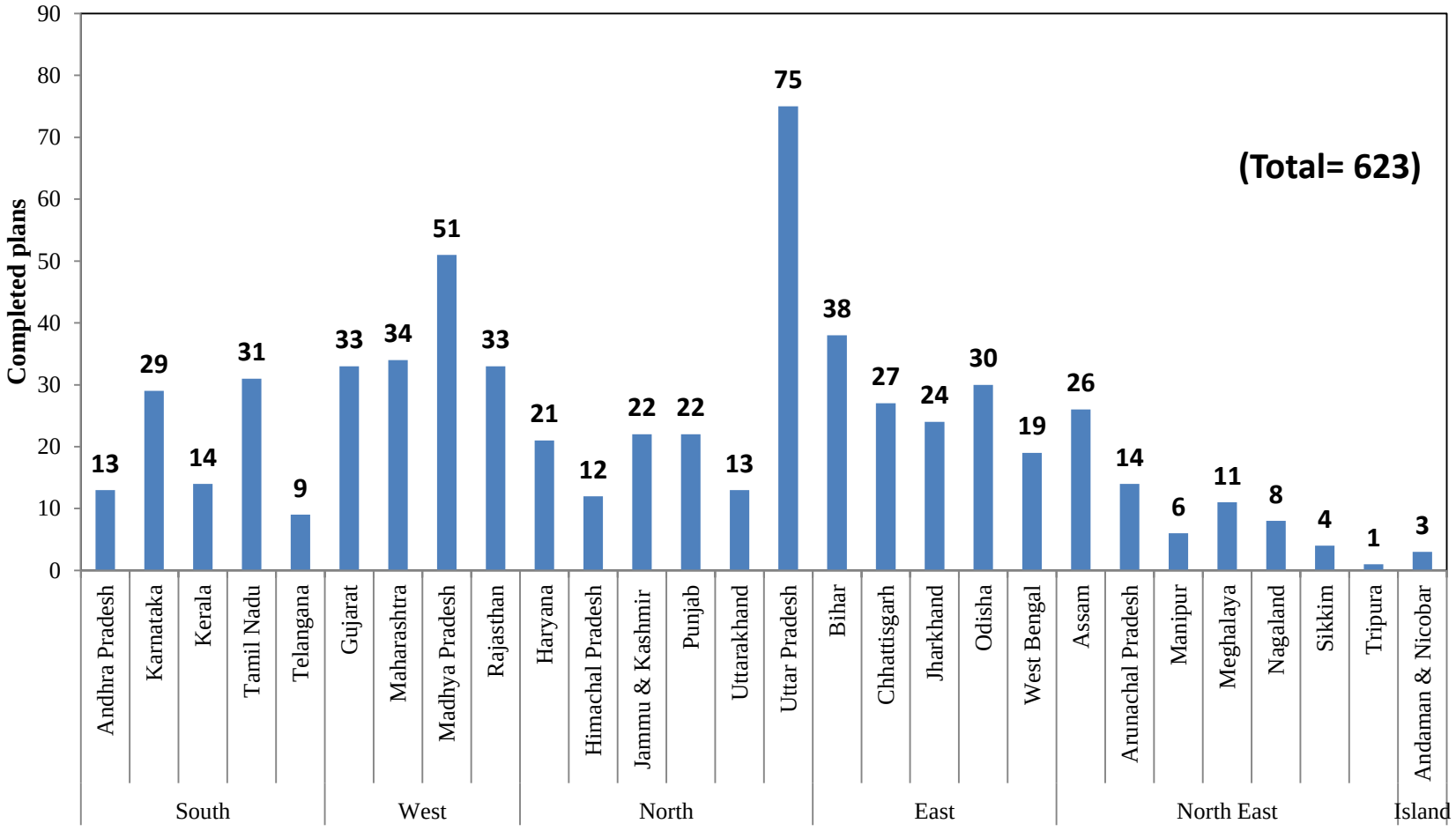
Suggested contingency measures:

- Change in variety, crop
- Appropriate Agronomic measures
- Implementation, linkage issues, sources of seed/ inputs, etc

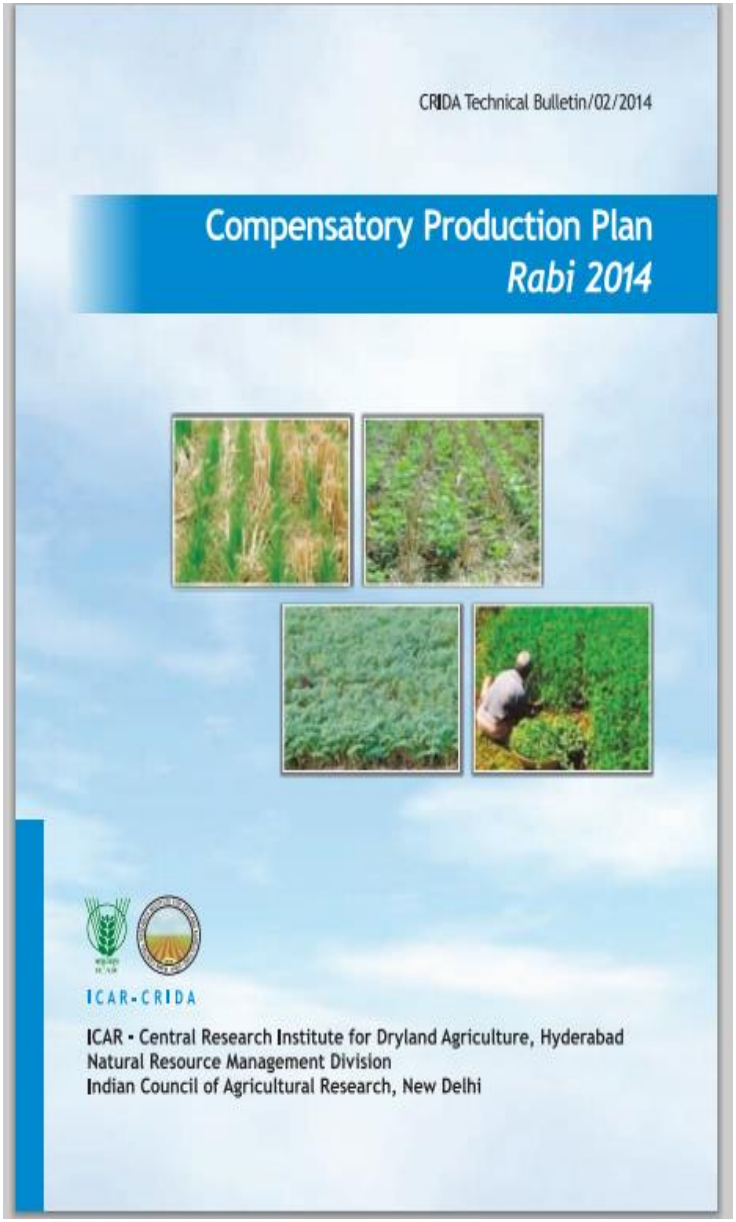
Contingency measures in 5 key Agricultural crops / Horticulture, Livestock, Poultry, Fisheries sectors

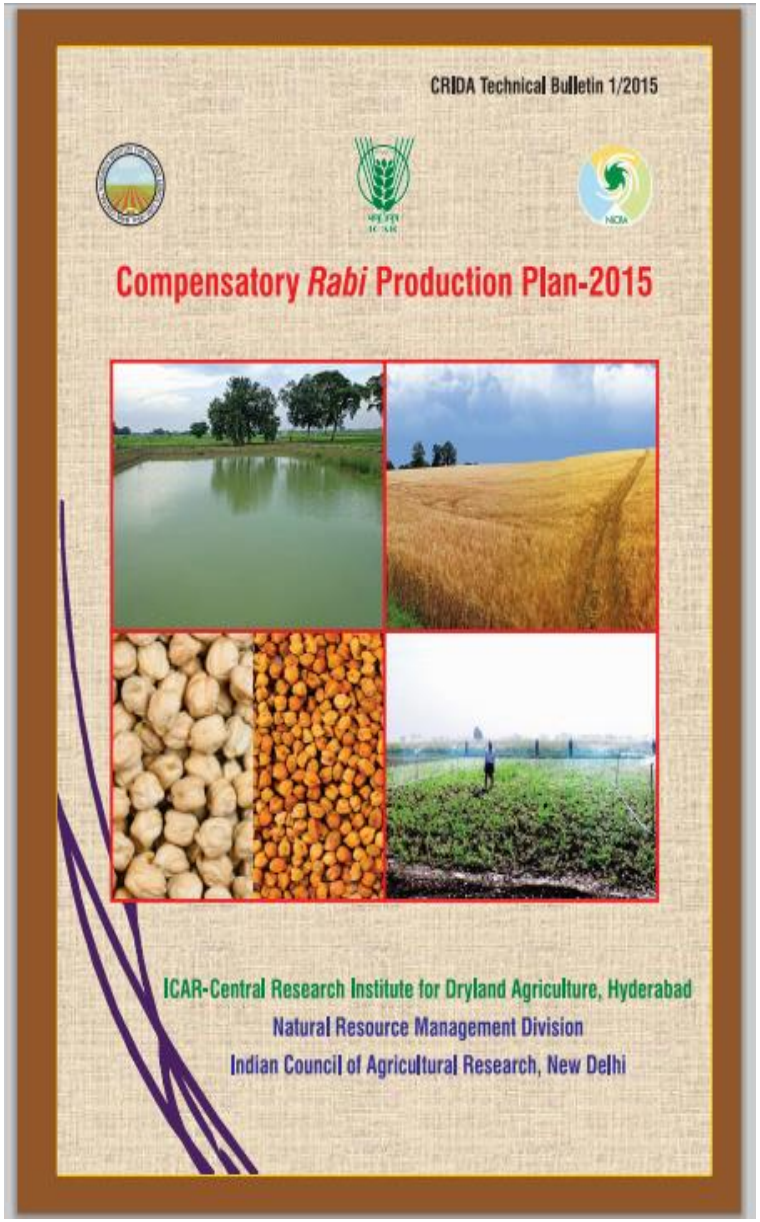
CRIDA

Status of District Agriculture Contingency Plans



Post Rainy Season (Rabi) Action Plan to Utilize Residual Moisture or Off-Season Rainfall





For further information:

www.crida.in

http://www.nicra-icar.in/nicrarevised/

Thank You