TRAINING MANUAL

APN Project on Building Capacity to Enhance Farmer's Capabilities to Address the Challenges of Climate Change Using Climate Smart Agriculture Strategies

Implemented by:

Amity University Uttar Pradesh, Noida, India

In collaboration with University of Western Australia, Australia, Kernel Foundation, Bangladesh and Kabul University, Afghanistan

Climate Resilient Technologies in Agriculture

Increasing global temperature, rising sea levels and melting polar ice caps result in land submergence, salinity intrusion, severe drought, frequent and more intense floods- all of which drastically impact agricultural productivity, food security and the livelihoods of millions of people in the affected regions. Experts of climate change, agriculture and other relevant fields of the South Asian countries came together to identify climate resilient technologies and practices that farmers can adopt in their fields to keep the productivity trends upward despite climatic hazards. The climate resilient technologies need to be selected on the basis of the agro-ecological systems of the respective regions. The selection criteria of climate smart technologies should prioritize the potential of the technologies to improve productivity, increase resilience and reduce greenhouse gas emissions. Resilient technologies should aim to achieve three outcomes:

- **Increased productivity:** Produce more food to improve food and nutrition security and boost the incomes of poor farmers who mainly rely on agriculture for their livelihoods.
- **Enhanced resilience:** Reduce vulnerability to drought, floods, salinity intrusion, pests, disease and other shocks; and improve capacity to adapt and grow in the face of longer-term stresses like shortened seasons and erratic weather patterns.
- **Reduced emissions:** Pursue lower emissions of GHGs for each calorie or kilo of food produced, avoid deforestation from agriculture and identify ways to suck carbon out of the atmosphere.

6.2 Intervention towards climate resilient agriculture

i) **Building resilience in soil:** Soil health is the key property that determines the resilience of crop production under changing climate. A number of interventions are suggested by the experts to build **soil carbon, control soil loss due to erosion and enhance water holding capacity of soils**, all of which build resilience in soil. **Soil mulching.**

ii) **Scaling up resilient crops and /or varieties:** Farmers usually grow local or high yielding varieties not capable of withstanding climate change shocks resulting in poor productivity or complete failure in case of climate extremes. South Asian countries have developed resilient crop varieties of various major crops. These **early & short duration, heat and flood/submergence tolerant Varieties** are to scaled up in the vulnerable regions to achieve optimum yields despite climate stresses.

iii) **Rainwater harvesting and recycling:** Rainwater harvesting and recycling through farm ponds, restoration of old rainwater harvesting structures in drought prone/rainfed areas, percolation of ponds for recharging of open wells, boring new wells and injection wells for recharging ground water, etc. for farm level water storage.

iv) **Water saving technologies:** Since climate variability manifests in terms of deficit or excess water, major emphasis should be laid on introduction of water saving technologies like **direct seeded rice**, **Alternative Wetting & Drying (AWD)**, **Zero-tillage** and other resource conservation practices which also reduce GHG emission besides saving of water.

v) **Intervention for livestock and fisheries sub-sectors:** Use of community lands for collective fodder production during droughts/floods, improved fodder/feed storage methods, feed supplements, use of micronutrient to enhance adaptation on heat stress, preventive vaccination, improved shelters for reducing heat/cold stress in livestock, improved management of fish ponds/ tanks during water scarcity and excess water, etc., are some key interventions in livestock/fishery sub-sectors.

Climate resilient technologies include zero tillage, raised bed planting, direct seeded rice, crop residue management and cropping diversification (horticulture, bee keeping, mushroom cultivation, etc.). Besides, site-specific nutrient management, laser levelling, micro-irrigation, seed/fodder banks, ICT-based weather advisories etc. They vary in different climate change hotspots as provided below.

Table 4: Climate Smart Technologies for Different Hotspots

Climatic Hotspot	Climate Smart Practices
Flood Hotspot	i) Flood tolerant crop cultivation. ii) Cultivation of submergence tolerant rice varieties. iii) Transplanting rice seedlings thickly in flood free land and after flood water recession transplanting in the main field and or transferring old seedlings from established crop fields to land from where flood water recedes lately. iv) Producing fruits and vegetables in the homestead area. Adjusting cropping calendar for avoiding flood v) Sorjan cultivation vi) Floating bed cultivation vii) Rice-duck system
Flash Flood Hotspot	i)Adjusting cropping calendar for avoiding flash floods ii) Short duration early varieties
Waterlogged Hotspot	i) Vegetable cultivation in floating beds. ii) Fruit and vegetables cultivation following Kandi method. iii) Cultivating aquatic vegetables

Salinity Hotspot	i) Cultivation of salinity tolerant rice varieties, salinity resistant- jute, peanut, sugarcane, kohlrabi, sweet potato, sesame, millet varieties, etc. ii) Water harvesting technology appropriate for farm water management iii) Practicing rice-fish-vegetables cultivation in the same land. iv) Crop through ditch & dyke, sorjan system and raised bed, floating beds to avoid saline water flooding.
Drought Hotspot	i) Fruits and vegetables production in the homestead area. ii) Cultivation of low water requiring crops like millets, maize, China, , kaon, cowpea etc. iii) Conservation of surface water by digging mini-ponds at the corner of the crop fields. iv) Using deep tillage and plant seedlings or sowing seeds at deeper layer of the soil. Using mulch in fruits and vegetables cultivation v) Relay cropping **vi)** Seed priming **vii) Rain water harvesting** **viii) Watershed devlopment**
Heat Stress	i) Heat Tolerant varieties ii)

6.3 Climate Resilient Technologies

Various climate resilient technologies and approaches are in the trial and some of which are in practices though in limited scale. In order to be scaled in wider geographic areas and to reach more farmers, these technologies must be documented, demonstrated at farm level. Stress tolerant technologies can be grouped into following category:

i) Cultivation of Stress Tolerant Crop Varieties

Rice: Various National and International research institutes have so far developed a number of stress tolerant rice varieties. IRRI has developed and released 42 drought-tolerant varieties that are now being cultivated by farmers in several countries. These include Sahbhagi dhan, CR dhan 204 and CR dhan 205, Sukkha dhan 4, Sukkha dhan 5, and Sukkha dhan 6 and BRRI Bangladesh has developed 17 stress tolerant varieties While Bangladesh Institute of Nuclear Agriculture (BINA) has developed four varieties (Table 5). IRRI has developed and released several drought-tolerant rice varieties like sahbahagi dhan, and DRR dhan 42 and 44 in India. Also in Afghanistan, various stress resistance varieties of rice such as Shishambagh -14, Zodrus -14, Jalalabad -14, Attaee -1, Red Bghlani and other released through the Agricultural Research Institute of Afghanistan (ARIA) of the Ministry of Agriculture, Irrigation and Livestock (MAIL) with the support of CGIAR's centres, JICA and other donors (Manan *et al*, 2020). Furthermore, the seed multiplication of rice is also run by ARIA and private sector under the umbrella of National Seed Board (NSB).

Table 5. Major stress-tolerant rice varieties in South Asia[1],[2]

Stress	Varieties developed
Drought	CR Dhan 40, CR Dhan 801, CR Dhan 802, Purna, Samrat, Abhishek(120 days duration)., Sahbhagi dhan (105-110 days duration in plain areas and 110-115 days in uplands, highly resistant to leaf blast and moderately resistant to brown spot and sheath blight), Naveen (115-120 days duration, released in 2005 for cultivation in Odisha), Anjali (90 days duration released in 2003 for Jharkhand), 'Birsa Vikas Dhan 109' (85 days duration) , Sushk Samrat, Swarna, IR64, Vandana, Anjali, Satyabhama, DRR dhan 42, DRR dhan 43,DRR dhan 44, BRRI dhan 56, BRRI dhan 57, BRRI dhan 66 , Birsa Vikas Dhan 203, Birsa Vikas Dhan 111, Rajendra Bhagwati, Jaldi Dhan 6, Sookha Dhan, Shishambagh 14, Zodrus 14 and Jalalabad 14
Submergence/waterlogged	Varshadhan, CR Dhan 501, Swarna Sub1, Gayatri, JalaMani, CR Dhan 505, CR Dhan 502, Jalnidhi, Jaladhi 1, Jaladhi 2, Sambha Mahsuri, $IR6_4$-Sub_1, BRRI dhan 51 and BRRI dhan 52; BINA dhan 11 and 12, Attaee 14
Salinity	BINA dhan 8, BINA dhan -10; BR-11, BRRI dhan 28, BRRI dhan 29, BRRI dhan 40, BRRI dhan 41 BRRI dhan 47, BRRI dhan 53, BRRI dhan 54, BRRI dhan 61, BRRI dhan 65, BRRI dhan 67, BRRI dhan-78, CSR 10, CSR 13, CSR 23, CSR-26, CSR 27, CSR 30, CSR 36, CSR 43, CSR-49, CR dhan 405,

IRRI and other partners have introduced the *SUB1* gene into eight “mega varieties” grown in several rice-growing countries in South Asia. These include Swarna-Sub1, Samba Mahsuri-Sub1, and Ciherang-Sub1 in India and Nepal and The use of these varieties are spreading fast over the last few years and are currently grown by more than 5 million farmers in Asia. In South Asia, seed multiplication and distribution of new flood-tolerant varieties is proceeding in Nepal, Bangladesh, and India in partnership with national agricultural research and extension systems.

Salt-tolerance is being incorporated into popular rice varieties and released in countries across Asia. From 2009 to 2016, four salt-tolerant rice (CSR 43, CR dhan 405 and 406, and Gosaba 5)

[1] https://icar-nrri.in/released-varieties/
[2] http://www.nicra-icar.in/nicrarevised/images/publications/Climate%20Resilent%20Crop_All%20Pages_12-03-19_low.pdf

have been released in India. During the same period, nine varieties tolerant of salinity rice, including stress-tolerant varieties are being disseminated in India and Bangladesh. In Bangladesh, various high yielding stress tolerant rice varieties have been developed by different institute & organization. Binahan-8,10 & 11 are the two stress tolerant varieties develop by BINA. Binadhan-8 and 10 are salt tolerant varieties which can tolerate up to 12 dS/m of salinity. Majority of rice varieties brought from abroad to Afghanistan. Some of them as Basmati 385, Sela Panjabi (Sela Zodrus) Garma Japani and etc, grow in different parts of the country (Ajir *et al*, 2019). Indeed, Afghanistan is still on the way to go for and strengthen the research on rice and other crops in various aspect such as salinity stress, diseases, waterlogging and etc.

Stress Tolerant Maize & Wheat Varieties

Drought-tolerant maize varieties developed by CIMMYT yield 2–3 tons ha−1 under drought conditions in which other varieties yield less than 1 tons ha−1 (Zaidi et al. 2004)[3]. Similarly, several hybrids of maize have been released in order to address the issue of heat, cold, or frost. For example, HQPM-1 and HHM-1 are tolerant to both cold and frost, while HM-1 is tolerant to frost only. The International Maize and Wheat Improvement Center (CIMMYT), which is collaborating with several national agricultural institutions and private sectors in South Asian countries in developing and deploying improved climate-resilient maize varieties, has achieved significant progress in developing and deploying elite heat-tolerant maize varieties. Wheat Research Centre in Bangladesh developed salt tolerant wheat varieties, Bijoy, BARI Gom-25; heat tolerant BARI Gom-26 when Bangladesh Agricultural University has developed wheat line BAU 1059 tolerant to salt condition. Since long back, ARIA has been working to release high yielding, drought and diseases' resistance varieties of wheat and other cereals in Afghanistan. Some of the drought resistance varieties are Lalmi-2, Lalami-1, Lalami-3, PBW-154, Herat-99, Dehdadi-13, Zarin-13, Mirdad-19, Sharq-19 and many others (Manan *et al*, 2020). Absolutely, in most researches ICARDA and CIMMYT are close collaborators that work on wheat and other cereal and legume crops. Other than that, seed multiplication of wheat crop is much better compare to other crops in Afghanistan. Fortunately, the seed multiplication of Maize, Paddy, Chickpea, other Legumes, some of the vegetables and oil crops and various fruit crops is carry out by ARIA and private sector (Noorzai *et al*, 2019). These stress tolerant varieties helping farmers to minimize yield loss and adapt to climate change (Table 6).

Table 6: Major stress-tolerant maize varieties in South Asia

Climatic Hazard	Variety

[3] Zaidi, P. H., Srinivasan, G., Cordova, H., & Sanchez, C. (2004). Gains from improvement for mid-season drought tolerance in tropical maize (Zea mays L.). Field Crops Research, 89, 135–152.

Drought	Pusa Hybrid Makka 1, HM 4, Pusa Hybrid Makka 5, DHM 121, Buland, MIMH1 and MIMH2, Zodrus-10, Sharq-8, Shamal-8, Maghzi-8
Submergence, deep water, waterlogging	HM-5, Seed Tech-2324, HM-10, PMH-2, TA-5084
Heat	YH-1898, KJ Surabhi, FH-793 ND-6339, NK-64017
	BHM14, BHM15
	RCRMH2, Lall-454, Zodrus-10, Sharq-8, Shamal-8, hybrid-1, hybrid-2, hybrid-3
	Rampur Hybrid-8, Rampur Hybrid-10
Cold and frost	HQPM-1, HHM-1, and HM-1

Table 7: Major stress-tolerant wheat varieties in South Asia

Climate Hazard	Variety of wheat	Country
Drought	PBW 527, HI 1531, HI 8627, HD 2888, HPW 349, PBW 644, WH 1080, HD 3043, PBW 396, K 9465, K 8962, MP 3288, HD 4672, NIAW 1415, HD 2987	India
	Dharabi, Ihsan, FSD-08, Khirman developed in Pakistan	Pakistan
	Lalmi-2, Lalmi-1, Lalmi-3, Lalmi-4, Lalmi-15, PBW-154, Herat-99, Dehdadi-13, Zarin-13, Mirdad -19, Sharq-19, Jawahir-19, Lalmi-17, Dima-17, etc.	Afghanistan
Heat	Jauhar, Gold, AAS, Ujala, Galaxy	Pakistan
	BARI Gom-26	Bangladesh
	K1114, NIAW1994, DBW107	India
	Lalmi-2, Lalmi-1, Lalmi-3, PBW-154, Herat-99, Dehdadi-13, Zarin-13, Mirdad-19, Sharq-19, etc.	Afghanistan
Salinity	KRL 213, KRL 210, KRL 19 and KRL 1–4	India
	Bijoy, BARI Gom-25, BAU-1059 line	Bangladesh
	Pasban, Uqab, Sehr	Pakistan

Table 8: Major stress-tolerant varieties of other crops in South Asia

Climate Hazard	Crop	Variety	Country
Salinity and Heat	Potato	BARI Alo-22	Bangladesh
	Sweet Potato	BARI Mishti Alo-8, BARI Mishti Alo 9	

	Pulses	BARI Mug- 2,3,4,5,6, BM-01, BM-08, BARI Falon- 1, BARI Sola-9,	
	Oil Crops	BARI Sharisha-14, BARI Sharisha 15, BARI Chinabadam -9, BINA Chinabadam-1,BINA *China badam-2,* BARI Soyabean-6, BARI Til-2,3,4	
	Sugarcane	ISWARDI-40	
	Jute	HC-2, HC 95, CVL 1	
Drought	Pulses	Bina masur-10	
	Chickpea	Flib-95, Flip-92, Flip-93, Rabat-13, Baghlan-13	Afghanistan
	Lentil	Koosk-1	
	Pistachio	Pistacia vera, UCB1,	
	Watermelon		
	Muskmelon		

Table 1: Crop Varieties Suitable for Cultivation under Drought Stress

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
Cereals					
Rice					
1.	Ashoka-200F	ACZ-IV B	ARS Banswara	Rajasthan	RSSC, Rajasthan
2.	Gujarat Nagli-4	ACZ	Very Heavy Rainfall Zone	Gujarat	DRNAU, Gujarat
3.	Kalinga, Sahbhagi dhan, IR-36	ACZ-II	Red and Laterite Zone	West Bengal	BCKV, Kalyani
4.	Kalinga-2, Kalyani-3, Narendar dhan 97	ACZ-I, ACZ-III	New Alluvial & Coastal Saline Zone	West Bengal	BCKV, Kalyani
5.	Pant Dhan 16, Barani, Dhan-1, Aditya, Kalinga-3	ACZ-III & II	NEPZ	Uttarakhand, Chhattisgarh	GBPUA&T, Pantnagar; IGKV, Jabalpur
6.	Pradhan, Poornima	ACZ-III	Bastar Plateau	Chhattisgarh	IGKV, Jabalpur
7.	Sahbhagi dhan, Sushak Samrat	ACZ-I, II & III	NEPZ & NWPZ, Southern alluvial zone	Bihar	BAU, Sabour
8.	Sukara Dhan-I, VL221	ACZ-II	Mid Hills Sub-Humid Zone	Himachal Pradesh	CSKHPKV, Palampur
9.	Naveen	ACZ-IV	Alluvial Plain Zone	Bihar	CRRI, Cuttack
10.	Prabhat	ACZ-IV	South Bihar Alluvial Plain Zone	Bihar	CRRI, Cuttack
11.	Abhishek	ACZ-IV	South Bihar Alluvial Plain Zone	Bihar	CRRI, Cuttack
12.	SARS-2	ACZ-XIII	Eastern Himalayan Region	Nagaland	CCA-NER shillong
13.	Dehangi	ACZ-XIII	Eastern Himalayan Zone	Arunachal Pradesh	Assam Agricultural University, Jorhat
14.	Vivek Dhan-154	ACZ-IX	Western Himalayan Region	Uttarakhand	BAU, Sabour
15.	Indira Barani Dhan-1	ACZ-IX	Eastern plateau and hill region	Chhattisgarh	IGKV, Raipur
16.	MTU-1010	ACZ-IX	Eastern Plateau and Hills Region	Madhya Pradesh	Andhra Pradesh Rice Research Institute (APRRI), Maruteru
17.	Sahbhagi dhan	ACZ-IX	Eastern Plateau and hills region	Orissa	BAU, Sabour
18.	MAS-26	ACZ-III	Southern Plateau And Hills Region	Karnataka	GKVK, UAS Bengaluru

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
19.	ANNA (R) 4	ACZ-IV	East Coast Plains and Hill Region	Tamil Nadu	TNAU, Coimbatore
20.	Tripura Khara 1, Tripura Khara 2, Tripura Hakuchuk 1, Tripura Hakuchuk 2, Tripura Aus	ACZ -III	Tripura	Tripura	ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra
21.	IR-64 Drt I (IET 22836) (DRR Dhan 42)			Telangana, Andhra Pradesh, Tamilnadu, Madhya Pradesh, Chhattisgarh, Jharkhand	IIRR, Hyderabad and BAU, Ranchi
22.	Birsa Vikas Dhan 111, Birsa Vikas Dhan 203			Jharkhand	BAU, Ranchi
23.	Sabour Shree (RAU 724-48-33)			Bihar	BAU, Ranchi
24.	Kalachampa			Odisha	Govt. of Odisha
25.	DRR Dhan 44 (IET 22081)			Uttarakhand, Haryana and Bihar	IIRR, Hyderabad
26.	DRR Dhan 43 (IET 22080)			Telangana, Puducherry, Kerala and Karnataka	IIRR, Hyderabad
27.	ADV 8301 (IET22410) Hybrid			Gujarat, Maharashtra, Andhra Pradesh and Telangana	Advanta Limited, Hyderabad.
28.	CR Dhan 101 (Ankit) (CR 2702) (IET 21627)			Odisha	NRRI, Cuttack
29.	DRR Dhan 46			Bihar, Madhya Pradesh and Maharashtra	IIRR, Hyderabad, Telangana
30.	JRH 19 Hybrid			Madhya Pradesh	JNKVV, Jabalpur
31.	PAC 129 (Arize 6129) Hybrid			Madhya Pradesh	Bayer Bio Science Pvt. Ltd
32.	BS 129G (Arize 6129 Gold) Hybrid			Chhattisgarh	Bayer Bio Science Pvt. Ltd, Hyderabad
33.	Nandyala Sona (NDLR 7) (IET 23715)			Andhra Pradesh	RARS, ANG RAU Nandyal
34.	Daksha (KMP-175)			Karnataka	ZARS, Mandya
35.	DRR Dhan 50 (IET 25671)			Andhra Pradesh, Telangana, Tamilnadu, Karnataka, Bihar, Odisha, Chhattisgarh, Uttar Pradesh and Madhya Pradesh	IIRR, Hyderabad
36.	CAU-RI (IET 23544)			Manipur and Meghalaya	CAU, Imphal

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
37.	VNR-2111 PLUS (IET 24075) (VNR 212)			Punjab, Uttarakhand, Haryana, Odissa, Bihar, West Bengal, Uttar Pradesh, Jharkhand, Madhya Pradesh, Chhattisgarh and Maharashtra	VNR Seeds Pvt. Ltd., Raipur
38.	ADT 51 (AD 09367) (IET 23617)			Tamil Nadu	Cauvery Delta districts of Tamil Nadu
39.	CR Dhan 801 (IET 25667) (IR 96322-34-223-B-1-1-1-CR3955-2)			Andhra Pradesh, Telangana, Odisha, Uttar Pradesh and West Bengal	IIRR, Hyderabad
40.	DRR Dhan 52 (IET 23354) (RP5125-12-5-3-B-IR84898-B			Haryana, Gujarat and Odisha.	IIRR, Hyderabad
41.	Ratnagiri-8 (RTN 28-1-5-3-2) (IET 25493)			Odisha, Uttar Pradesh, Chhattisgarh, Maharashtra, Andhra Pradesh and Telangana.	ARS, Shirgaon, Ratnagiri
Wheat					
42.	HD2888, K8027	ACZ-I, II, III	NEPZ	Bihar, Eastern UP, West Bengal	BAU, Sabour
43.	Sujata, C-306, JWS-17, HI-8627, HI-1531	ACZ-II	Northern Hills	Chhattisgarh	IGKV, Jabalpur
44.	HPW-155, HPW-236	ACZ-III	High Hills Temperate Wet Zone	Himachal Pradesh	CSK HPKVV, Palampur
45.	VL421, HS277, VL Gehun 829, HPW249, VL907, HS420, HPW236	ACZ-I &II	NHZ	Himachal Pradesh	CSK HPKV, Palampur
46.	PBW 644, PBW 527, PBW 175	ACZ-I, II, III, IV, V	NWPZ	Punjab	PAU, Ludhana
47.	HI-1500	ACZ-IV A	Sub-humid southern plains and Aravalli Hills	Rajasthan	IARI, RS, Indore
48.	Raj 3077, Raj 3765, KRL-1-4	ACZ-II-B	Transitional Plan of Luni Basin, Jaipur	Rajasthan	RSSC, Rajasthan
49.	UP1109, UP2572	ACZ-I	NHZ	Uttarakhand	GBPUA&T, Pantnagar
50.	PBW 527, PBW 644, PBW 396		North Western Plain Zone	Punjab, Haryana, UP, Rajasthan	PAU, Ludhiana
51.	HI 1531 and HI 8627		Central Zone	MP, Rajasthan	IARI, Indore
52.	DBW 110, MP 3288, MP 3173, HI 1531, HI 1500		Central Zone	MP, Rajasthan	DWR, Karnal; IARI, Indore; JNKVV, Jabalpur

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
53.	NIAW 1415, HD 2987, HD 2781		Peninsular Zone	Karnataka, Maharashtra	MPKV, Niphad; IARI New Delhi
54.	WH 1080, HD 3043		North Western Plain Zone	Punjab, Haryana, UP, Rajasthan	CCS HAU, Hisar; IARI, New Delhi
55.	Netravati	ACZ-IX	Middle Gangetic Plain Region	Bihar	MPKV Regional Station, Niphad, Rahuri.
56.	RAJ-4120	ACZ-IV	Central Plateau and Hills Region	Rajasthan	RARS, Durgapura, Jaipur
57.	Ratan	ACZ-IV	Central Plateau and Hills Region	Rajasthan	RARS, Durgapura, Jaipur
58.	RVW-4106	ACZ-IV	Central Plateau and Hills Region	Madhya Pradesh	RVSKVV, Gwalior
59.	WSM -1472	ACZ-IV	Western Plateau and Hills Region	Maharashtra	MPKV, Niphad; IARI New Delhi
60.	K-307	ACZ-IX	Eastern Plateau and Hills Region	Jharkhand	CSAUA&T, Kanpur
61.	K-9107	ACZ-IX	Eastern Plateau and Hills Region	Jharkhand	CSAUA&T, Kanpur
62.	KRL-213	ACZ-II	Trans Gangetic Plain region	Haryana	CSSRI, Karnal
63.	DBW-17	ACZ-IX	Eastern Plateau and Hills Region	Uttar Pradesh	IIW&BR, Karnal
64.	WH 1142			Punjab, Haryana, Delhi, Rajasthan, Western Uttar Pradesh and plains of Jammu and Kashmir, Himachal Pradesh, Uttarakhand	CCSHAU, Hisar
65.	UAS 347			Maharashtra and Karnataka	UAS, Dharwad, Karnataka
66.	Sabour Nirjal (BRW 3723)			Bihar	Bihar Agril. Univ. Sabour, Bihar
67.	HUW 669 (Malviya 669)			Uttar Pradesh	IAS, BHU, Varanasi
Maize					
68.	Suwan	ACZ-I	North eastern plain zone	Bihar	BAU, Sabour / RAU, Pusa
69.	HQPM-5, HQPM-1	ACZ-III	Bastar Plateau	Chhattisgarh	IGKV, Raipur
70.	Vivek-21, Vivek-9	ACZ-II	Northern Hills	Chhattisgarh	Private dealers/sectors
71.	Nithyashri, Hema (NAH-1147)	ACZ-IV, V, VI	Central, Eastern, Southern Dry Zone	Karnataka	NSP, GKVK, UAS(B) / KSSC/NSC
72.	PMH-2, Parkash	ACZ-III	Central Plain Zone	PUNJAB	PAU, Ludhiana
73.	Mahi Dhawal	ACZ-IV B	ARS Banswara	Rajasthan	RSSC, Rajasthan

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
74.	PEHM-1, Pratap Makka-5, Pratap Makka-3, Pratap Hybrid Makka-1	ACZ-IV A	Sub-humid southern plains and Aravali Hills	Rajasthan	IARI, New Delhi
75.	HM 4		North Western Plain Zone and Southern Zone	Haryana, UP, AP, Maharashtra	CCS HAU, Karnal
76.	Birsa Makka-1	ACZ-IX	Eastern Plateau and Hills Region	Jharkhand	BAU, Ranchi
77.	Mukta	ACZ-IV	Central Plateau and Hills Region	Rajasthan	IARI, New Delhi
78.	JM-216	ACZ-IX	Chhattisgarh Plain Zone	Madhya Pradesh	JNKVV, Chhindwara
79.	Suwan-1	ACZ-IX	Eastern Plateau and Hills Region	Jharkhand	BAU, Ranchi
80.	Bajaura makka	ACZ-XIII	Western Himalayan Region	Himachal Pradesh	HPKVV, RS, Kullu
81.	Girija	ACZ-XIII	Western Himalayan Region	Himachal Pradesh	HPKVV, RS, Kullu
82.	KMH-7148 Hybrid			Punjab, Haryana, Delhi and Uttar Pradesh	Kaveri Seed Company Limited, Secundrabad
83.	Candy (KSCH-333) Hybrid			All India	Kaveri Seed Company Limited, Secundrabad, Telangana
84.	D2244 (DAS-Maharashtra-501) Hybrid			All India	DOW Agro Sciences India Pvt Ltd., Mumbai.
85.	GK 3150 Hybrid			Punjab, Haryana, Delhi and Uttar Pradesh	Ganga Kaveri Seeds Pvt.Ltd., Hyderabad
86.	DRONA (KMaharashtra-2589) Hybrid			Punjab, Haryana, Delhi, Uttar Pradesh, Andhra Pradesh, Telangana, Maharashtra, Karnataka and Tamil Nadu	Kaveri Seeds Company Ltd., Secunderabad
87.	MAH-14-5			Karnataka	ZARS, V.C. Farm, Mandya
88.	Pusa Jawahar Hybrid Maize-1			Madhya Pradesh	
Pearl millet					
89.	GHB-538 and GHB-719	ACZ-III, IV, V, VI, VII & VIII	Middle, North Gujarat, South Shurashtra	Gujarat	JAU, Jamnagar
90.	WCC-75	ACZ-IV, VI	Central Dry Zone, Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
91.	Raj-171	ACZ-II-A	Fatehpur	Rajasthan	RSSC, Rajasthan

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
92.	GHB-538, RHB-177	ACZ-I-A, I-C	Arid Western Plains, Hyper arid and Western Plains	Rajasthan	RSSC, GSSC, NSC
93.	HHB-67(I), RHB-177	ACZ-II-B	Plan of Luni Basin, Jaipur	Rajasthan	RSSC, Rajasthan
94.	RBH-177, RBH-154, RBH-173	ACZ-III-A	Semi-arid Eastern Plains, Jaipur	Rajasthan	RSSC, Rajasthan
95.	HHB-234, HHB-226, HHB-216, Bio 70 (MH 1632), RHB-177, RHB-154, GHB-757, GHB-719, GHB-538, CZP 9802	ACZ-I	NWPZ, West zone	Western Rajasthan, Gujarat & Haryana	CCS HAU, Hisar; Bioseed Pvt Ltd; ARS Durgapura; AICPMIP MRS Jamnagar; CAZRI Jodhpur
96.	NBH 5061 (MH 1812) Hybrid			Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu	Nuziveedu Seeds, Hyderabad
97.	NBH 5767 (MH 1785) Hybrid			Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu	Nuziveedu Seeds, Hyderabad
98.	PBH – 306 (MH 1962) Hybrid			Maharashtra, Karnataka, Telangana, Andhra Pradesh and Tamil Nadu	PrabhatAgri Biotech Limited, Hyderabad
99.	AHB 1200 Fe (MH 2072 (AHB 1200) hybrid			Rajasthan, Gujarat, Haryana, Punjab, Delhi, Maharashtra, Telangana, Andhra Pradesh and Tamil Nadu	VNMKV, Parbani
100.	PB 1705 (MH 2008) Hybrid			Rajasthan, Gujarat, Haryana, Punjab, Delhi, Madhya Pradesh and Uttar Pradesh	Bayer Bio Science Pvt. Ltd. Hyderabad
101.	BHB-1202 (Bikaner **Hybrid** Bajra-1202) (MH 1831)			Rajasthan	SKRAU, Bikaner (Raj.)
Barley					
102.	PL-419	ACZ-I, II, III, IV, V	NWPZ, NEPZ	Punjab	PAU, Ludhiana
103.	K603	NEPZ	NEPZ	UP, Bihar	CSAUAT, Kanpur
104.	RD2660	ACZ-IV	NWPZ	Rajasthan, UP, Haryana	RARS, Durgapura, Jaipur
105.	RD-2592	ACZ-IV	Central Plateau and Hills Region	Rajasthan	RARS, Durgapura, Jaipur
106.	JB-58	ACZ-IV	Central Plateau and Hills Region	Madhya Pradesh	RARS, Rewa, MP
Foxtail millet					
107.	RS-118, K-211-1, PS-4, SIA-326	ACZ-IV, VI	Central & Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
108.	HHB-67	ACZ-II	Western Dry Region	Rajasthan	CAZRI, Jodhpur
109.	MPMH-17	ACZ-II	Western Dry Region	Rajasthan	CAZRI, Jodhpur
110.	HA-4	ACZ-IV	Southern plateau and Hills region	Karnataka	UAS Bengaluru
Finger millet					
111.	VR-708 (Padmavati), HR-374	ACZ-III	Bastar Plateau	Chhattisgarh	IGKV / NRC millets Bangalore
Little millet					
112.	Jawahar Kutki 4 (JK 4)			Madhya Pradesh	JNKVV, Rewa, Madhya Pradesh
Kodo millet					
113.	Jawahar Kodo 137			Chhattisgarh	IGKV, COA&ARS, Jagdalpur, Bastar
114.	MR-1, MR-6, GPU-66, GPU28, KMR-301, ML-365	ACZ-V, VI, IV	Central, Eastern, Southern Dry Zone	Karnataka	GKVK, UAS(B) / KSSC
115.	Phule Nachani	ACZ	Sub montane Ghat Zone of Maharashtra State	Maharashtra	MPKV, Rahuri; ZARS, Kolhapur, Maharashtra
116.	Ragi 404			Jharkhand	VPKAS, Almora
117.	PRM-1	ACZ-XIV	Western Himalayan Region	Uttarakhand	Hill Campus, GBPUA& T, Ranichauri
118.	Suryanandi	ACZ-III	Southern Plateau and Hills Region	Andra Pradesh	ANGRAU, Guntur
119.	Indira Ragi-1	ACZ-IX	Eastern plateau and hill region	Chhattisgarh	IGKV, Jagdalpur
120.	Co-15	ACZ-VIII	East Coast Plains and Hills Region	Tamil Nadu	TNAU, Coimbatore
121.	Vakula (PPR 2700)			Karnataka	ARS, Perumalapalle, Andhra Pradesh
122.	Chhattisgarh Ragi-2 (BR-36)			Chhattisgarh	IGKVV, Raipur, Chhattisgarh
Sorghum					
123.	CSH-5, CSH-9, CSV-4, DSV-2	ACZ-VI	Southern Dry Zone	Karnataka	GKVK, UAS(B)/ KSSC / NSC
124.	Parbhani Moti	ACZ-I	Marathwada Region	Maharashtra	VNMKV, Parbhani
125.	CSV-17	ACZ-IV A	Sub-humid southern plains and Aravali Hills	Rajasthan	ARS, Udaipur
126.	Pant Chari 5, Pant Chari 7	ACZ-I	NHZ	Uttarakhand	GBPUA&T, Pantnagar;

Sl. No.	Varieties	Zone	Sub-Zone	State	Source of seed availability
127.	M-35-1, Phule Chitra, Phule Vasudha, Phule Panchami, CSH19R, CSV 18		Rabi Sorghum growing area	Maharashtra	MPKV, Rahuri
128.	Phule Anuradha	ACZ-IV	Western Plateau and hills region	Maharashtra	MPKV, Rahuri
129.	CSV 32F (SPV 2128)			Maharashtra, Tamil Nadu and Karnataka	IIMR, Hyderabad
130.	Phule Rohini (RPASV3)			Maharashtra	MPKV Rahuri
131.	Phule Madhur (RSSGV 46)			Maharashtra	MPKV Rahuri, Ahmednagar
132.	RVICSH 28 (Hybrid)			Madhya Pradesh	All India Coordinated Sorghum Improvement Project, Indore
Barnyard millet					
1.	PRJ-1	ACZ-XIV	Western Himalayan Region	Uttarakhand	GBPUA&T, Pantnagar
Sugar Crops					
Sugarcane					
1.	Co 86032, Co 85019, Co 94008, Co 94012, Co 99004, Co 2001-13, Co 0218, Co 0403 and Co 06027	Peninsu-lar zone		Tamil Nadu, Karnataka, Maharashtra	SBI, Coimbatore
2.	Co 2001-15, Co 98014, Co 0238, Co 0118, Co 0124, Co 0239	North Zone		UP, Haryana, Punjab, Bihar	SBI RS, Karnal, Lucknow
3.	Sankeshwar 049 (Co Snk 05103)			Andhra Pradesh, Gujarat, Maharashtra, Karnataka, Tamil Nadu, Kerala and Madhya Pradesh	UAS ARS, Sankeshwar
4.	Sankeshwar 814 (Co Snk 05104)			Andhra Pradesh, Gujarat, Maharashtra, Karnataka, Tamil Nadu, Kerala and Madhya Pradesh	UAS ARS, Sankeshwar
5.	CoBIn 02173(22/94) D01YANG			Assam	AAU RS, Buralikson, Golaghat, Assam
6.	CO 0212			TamilNadu	SBI, Tamil Nadu
7.	Gujarat Sugarcane 5 (CoN 05071)			Gujarat	NAU, Navsari

ii) Practicing Resilient Management Practices

Changing the cropping pattern, introducing new crops or replacing existing crops, or changing crop sequence can be a way to climate change adaptation. In drought-prone areas of India, farmers use drought-adapted crops such as sorghum and also adjust their production practices as a mechanism to spread risk such as staggered planting. Farmers use leguminous crops, mostly red grams, mung bean, and peanuts, to supplement nitrogen to the soil which is lost due to soil erosion or excess flooding. In the regions with cool and humid climate, legumes are planted/mixed with the main crop, to protect the fallow land. A recent study in Ludhiana of India shows that shifting planting date of wheat and transplanting date of rice to 15 days earlier than the usual date could minimize yield loss by more than 4% (Jalota et al. 2013)[4].

Water Management

Integrated water management, which promotes an alternative use of waste and marginal water for agriculture, can be an important approach to adapt agriculture to water stress. Water harvesting, is an age-old practice of collecting rainwater in India. A significant amount of water saving was also observed in rice (26–30%), wheat (26–33%), maize (22–33%), and cotton (26–43%) in laser land levelled fields (Jat et al. 2014)[5]. Similarly, the application of a micro-irrigation system (sprinkler and drip) can help to save water from 12 to 84%, depending on location and crops under micro-irrigation (Kumar 2016)[6]. System of rice intensification (SRI) is a set of crop, soil and water management practices in which 8–15 days old seedlings are transplanted singly and irrigated intermittently to keep rice fields only moist, but aerated. Compared to flooded system, SRI is reported to increase crop yield by more than 10% with less water consumption (i.e. 25–47% less water) in India (Barah 2009)[7], China (Wu et.al.,2015)[8]. Both by reducing cost of production and by increasing yield, SRI helps increase the farmers' income thereby enhancing their adaptive

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[4] S.K. Jalota et al., 2013. Productivity of rainfed wheat as affected by climate change scenario in northeastern Punjab, India

[5] R.K. Jat, T.B. Sapkota, R.G. Singh, M.L. Jat, M. Kumar, R.K.GuptaSeven years of conservation agriculture in a rice-wheat rotation of Eastern Gangetic Plains of South Asia: yield trends and economic profitability Field Crop Res., 164 (2014), pp. 199-210

[6] M. Dinesh Kumar, 2016. Water Saving and Yield Enhancing Micro Irrigation Technologies in India: Theory and Practice:DOI:10.1007/978-981-10-0348-6_2 Corpus ID: 156197767

[7] Barah, B. C. (2009). Economic and ecological benefits of System of Rice Intensification (SRI) in Tamil Nadu. Agricultural Economics Research Review, 22, 209–214.

[8] Wu, W., Ma, B., & Uphoff, N. (2015). A review of the system of rice intensification in China. Plant and Soil, 393(1–2), 361–381. 166. Ye, Y., Liang, X., Chen, Y., Liu, J., Gu, J., Guo, R., et al. (2013). Alternate wetting and drying irrigation and controlled-release nitrogen fertilizer in late-season rice. Effects on dry matter accumulation, yield, water and nitrogen use. Field Crops Research, 144, 212–224.

capacity. Further, SRI crop matures earlier thereby reducing the risk of crop losses and make land available for other crops. In addition, rice plants grown with SRI practices, by having stronger tillers and root systems and tougher leaves, are more resistant to the biotic and abiotic stresses that accompany climate change such as heat stress, drought stress, flooding, storm, and disease damage (Wu et al. 2015).

Table 9: Water management practices for climate change adaptation

Practices	Adaptation to water stress	References
Alternate wetting and drying (AWD)	Reduces almost 30% water use in rice production as compared to a conventional flooding system without reducing rice yield	Gathala et al. (2013) and Ye et al. (2013)
Direct seeding of rice (DSR)	Saves water and help adapt to water stress	Pathak et al. (2013)
Improved irrigation methods	Micro-irrigation system (sprinkler and drip) saves 12–84% of water	Kumar (2016)
Laser land levelling	Reduced irrigation time in rice by 47–69 h ha^{-1} $season^{-1}$ and wheat by 10–12 h ha^{-1} $season^{-1}$	Aryal et al. (2015a)
	Water saving in rice (26–30%), wheat (26–33%), maize (22–33%), and cotton (26–43%)	Jat et al. (2015)

Source: Climate change and agriculture in South Asia: adaptation options in smallholder production systems.

India has initiated several programs to address water paucity region wise. Integrated Wasteland Development Programme (2001), Desert Development Programme (1973–1974) and Drought-Prone Area Programme (1977–1978) were started to mitigate causalities of desertification and drought-affected areas, promote dryland farming, create employment opportunities, bring wasteland under cultivation to improve agricultural productivity due to increased demand for grains, and utilize rainwater for irrigation.

Sustainable Land Management

Sustainable land management practices such as agroforestry, conservation agriculture, sustainable intensification, and cropping system optimization all contribute to climate change adaptation. Sustainable intensification acknowledges that enhanced productivity needs to be accompanied by the Sustainable intensification may be achieved through a wide variety of means. Farmers in Haryana and Punjab states of India have adjusted their agricultural practices to rainfall variability and declining groundwater table by using laser land levelling and practicing conservation agriculture.

Laser land levelling can substantially increase water- and nutrient-use efficiency, thereby adapting agriculture to water stress condition. Using zero till on wheat production system yields both economic and environmental benefits. A study by Aryal et al. (2015b)[9] in Haryana shows that farmers can save approximately USD 79 ha^{-1} in input costs and increase net revenue of approximately USD 97.5 ha^{-1} under zero tillage-based wheat production compared with conventional tillage. They also showed that zero tillage-based wheat production reduces GHG emission by 1.5 Mg CO_2-eq ha^{-1} wheat-$season^{-1}$.

Agroforestry (i.e., cultivation of woody perennials with agricultural crops on the same unit of land) enables not only to sequester carbon but also to adapt agriculture to droughts, floods, and other natural disturbances. Similarly, Silvo-pastoral systems, which combine the grazing of livestock and forestry, are particularly useful in reducing land degradation, where soil erosion risk is high. Under the agroforestry system, leaf litter gets decomposed when mixed with an aerobic and anaerobic microorganism. Such a process improves soil fertility, reduces water runoff, and controls soil erosion, which eventually increases resilience to climatic variability. In India, it is common to plant trees like Eucalyptus and Populous in the agricultural fields, particularly on farm boundaries. This provides a win–win situation for rural farmers as they obtain double income: one from trees—producing fruits, timber, flowers, and medicines—and the other from the crops grown.

Crop Pest and Disease Management

Crop pest and disease management is crucial for adapting agriculture to climate change. Increasing climatic variability may create favourable conditions for pests and diseases. With the rising temperature, range of crop pests and diseases are projected to expand to higher latitudes. Global yield losses due to insect pests of three staple grains (i.e., rice, wheat, and maize) are projected to increase by 10–25% per degree of global mean surface warming, and such losses will be more acute in temperate regions (Deutsch et al. 2018)[10]. Governments in South Asian countries emphasize on integrated pest management to tackle the increasing emergence of pests and diseases and have provided training to farmer.

6.4 Climate Resilient Practices in Bangladesh, India and Afghanistan

Scientists and farmers in South Asia ie Bangladesh, India and Afghanistan have developed some resilient practices for crop cultivation against climatic shocks. Farmer's practiced in different climatic hotspot are provided in the following paragraphs:

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[9] Aryal, J.P., Sapkota, T.B., Jat, M.L., & Bishnoi, D.K., 2015b. On-farm economic and environmental impact of zero-tillage wheat: A case of North-west India. Experimental Agriculture, 51(1), 1-16. https://doi.org/10.1017/S001447971400012X

[10] Deutsch et al. 2018. Increase in crop losses to insect pests in a warming climate: *Science* 31 Aug 2018:Vol. 361, Issue 6405, pp. 916-919. DOI: 10.1126/science.aat3466

i) **Flood prone areas:** In the flood prone areas farmers:

- Use of tomato grafted on brinjal root stocks to withstand drought and flood have been standardized for different locations with location specific root stocks
- Use aged seedlings for survival in the flooding condition;
- Transplant seedlings thickly in flood free land and transfer to the main field after recession of flood water
- Transfer old seedlings (tillers) from established crop field to land from where flood water recedes lately;
- Cultivate pistachio and forest nuts trees in hilly flood prone areas
- Pasture management and grasses in flood prone areas
- Cultivate quick growing vegetables, millets, maize etc.
- Grow flood resistant rice varieties

ii) **Waterlogged areas**: In the waterlogged areas farmers cultivate-

- Winter rice by pumping out water;
- Cultivate aquatic vegetables
- Cultivate local forest resistance to waterlogged areas

iii)Drought prone areas: In drought prone areas

During summer season farmers-

- Dig small tank or ditches at the corners of the crop field and hold flood water for supplementary irrigation by indigenous methods or hose pipe;
- Avoid drought in pick period by early or late planting of rice;
- During winter season:
- Use deep tillage and plant seedlings or sow seeds at deeper layer of soil;
- Adjust crop calendar to avoid drought;
- Use mulches in high value crops like tomatoes, potatoes;
- Practice relay cropping;
- Grow shade trees in the crop field;
- Cultivate rain-fed wheat, chickpea, watermelon, and some other crops
- Cultivate pistachio, forest nuts trees, and fruit crops resistance to drought
- Irrigate crop field at critical growth stages (tillering and panicle initiation stage of wheat, tuberization stage of potatoes).
- Preparation of low cost water harvesting structures
- Use of climate smart crop varieties/cultivars tolerant to abiotic stresses in rice, wheat, maize, pigeonpea, blackgram, greengram, tomato, onion; livestock breeds
-

iii) **Saline prone areas**: In the saline prone area farmers-

- Cultivate saline tolerant crops such as groundnut, water melon, kohlrabi, turnip, maize, potatoes, millets, etc.;

- Practice low-cost irrigation methods like use of swing, treadle pump and other indigenous techniques of irrigation;
- Cultivate vegetables in raised beds or mounts, on dykes or on floating beds;
- Cultivate beans, gourds, okra and other vegetables on the embankments surrounding prawn *Ghers or* ponds,
- Practice rice-fish-vegetables cultivation in the same plot of land,
- Use ditch and dyke and sorjan system of planting to avoid saline water flooding,

Fisheries: Fishers' practices are:

- Netting of fish ponds or *Ghers;*
- Use shifting techniques for fish culture (transferring stock from dense pond to field;
- Practice case culture in household ponds or in small water bodies;
- Culture brackish fish species/strains developed by Fishery research,
- Practice prawn fish poly-culture in fresh water *Ghers* (ponds),
- Shrimp fish poly-culture in fresh water *Ghers* (ponds),
- Crab fattening.

Livestock:

- Rearing livestock in the homestead area (tala model),
- Rearing local adaptive species (sheep, buffalos, duck) best suited in the region,

NATIONAL INNOVATIONS ON CLIMATE RESILIENT AGRICULTURE (NICRA), INDIA SUCCESS STORIES

(http://www.nicra-icar.in/nicrarevised/index.php/publications/success-stories)

National Innovations on Climate Resilient Agriculture (NICRA) is a network project of the Indian Council of Agricultural Research (ICAR) launched in February, 2011. The project aims to enhance resilience of Indian agriculture to climate change and climate vulnerability through strategic research and technology demonstration. The research on adaptation and mitigation covers crops, livestock, fisheries and natural resource management. The project consists of four components viz. Strategic Research, Technology Demonstration, Capacity Building and

Sponsored/Competitive Grants. Here we share some of the success stories of NICRA taken from NICRA

Insitu moisture conservation under Zero Tillage

Low cost water harvesting structure -Jalkund/ Vegetable cultivation during Rabi Season

Vermicomposting

Intercropping of broccoli (variety Ashwarya) with pea (local variety)

System of Rice Intensifiaction

Intercropping of cabbage with pea (local variety)

Integrated farming system (Fishery+Piggery+Vegetables)

Integrated farming system (Paddy cum fish culture)

Year Round Vegetable Production

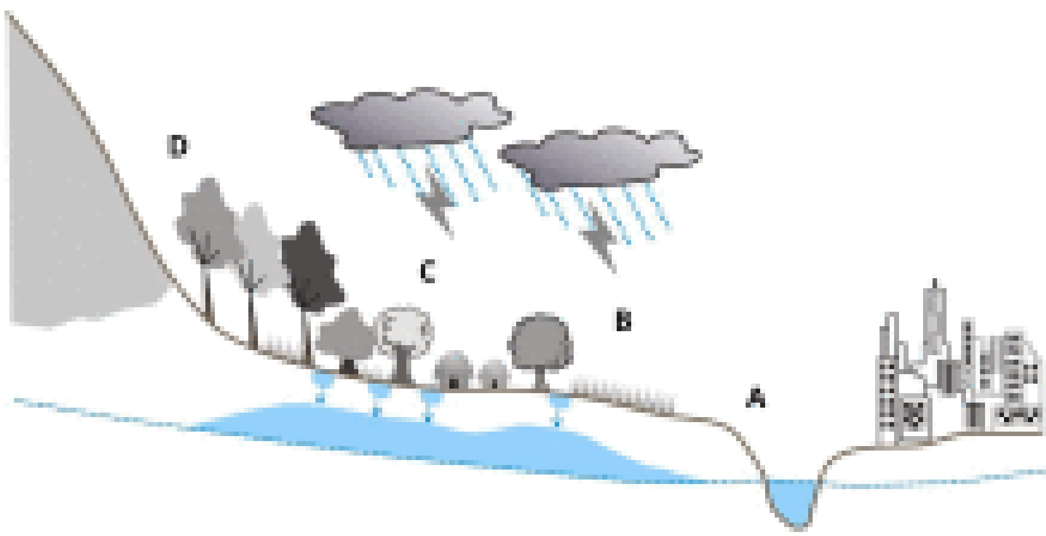
Polyhouse cultivation

Composite fish culture

Village level weather station

Low cost Checkdams and Drip Irrigation

Cultivation under low poly tunnel



Underground Transfer of Floods for Irrigation(UTFI) reduces the intensity of seasonal floods by tapping and storing flood waters in aquifers for productive use[11]

[11] https://doi.org/10.1016/j.jhydrol.2019.124518 (V.Ratna Reddy, Sanjit KumarRouta ,SarahShalsi Paul ,and Pavelic AndrewRoss (2020)Managing underground transfer of floods for irrigation: A case study from the Ramganga basin, India, Journal of Hydrology, Volume 583, April 2020, 124518

Other success stories from India

Drum seeding of rice for water saving and timeliness in planting[12]

Drum seeding in operation

Observing crop stand few days after seeding

Crop at maturity stage

[12] https://vikaspedia.in/agriculture/crop-production/crop-management-for-aberrant-weather-conditions/smart-practices-technologies/drum-seeding-of-rice-for-water-saving-and-timeliness-in-planting

furrow irrigated raised bed (FIRB) planting and Broad bed and furrow (BBF)[40]

Resilient practice / technology

There is a need for in-situ soil and water conservation and proper drainage technology in deep black soils. Broad bed and furrow (BBF) system involves preparation of a broad bed of 90 cm, furrow of 45 cm and sowing of crop at a row spacing of 30 cm. The cost of BBF implement is Rs. 45,000. The BBF technology has many advantages including in-situ conservation of rainwater in furrows, better drainage of excess water and proper aeration in the seedbed and root zone. More than 200 farmers in Sanora and Barodi village adopted the technology. Similarly, furrow irrigated raised bed (FIRB) planting was promoted for cultivation of different crops in Uttar Pradesh, West Bengal, Punjab, Maharashtra, Karnataka, Rajasthan and Tamilnadu. Ridge and furrow method of vegetable cultivation was promoted in Gunia village of Gumla district and in cotton at Amravati and Aurangabad, Maharashtra.

Impact

Advantage of BBF planting method :

- Increase in water use efficiency
- Increase in crop productivity (5-10%)
- Less moisture stress during non- rainy days
- Time saving (25-30%) in irrigation
- Requires 20-25% lower seed rate
- Water saving up to 25-30%
- Better weed management

Prepration of broad beds

Rainwater in furrows

Crop stand with BBF planting

FIRB planting in wheat

- Reduces crop lodging

IPM Packages to manage pest and disease

IPM components used in the demonstrations

- Use of resistant / tolerant varieties
- Seed treatment with *Trichoderma viride* and *Pseudomonas fluorescence*
- Soil treatment with Neem cake
- Seedlings treatment with *Trichoderma viride* + *Pseudomonas fluorescence*
- Pheromone traps for monitoring fruit borers
- Yellow sticky traps for monitoring of soft bodied insects
- Bio-pesticides such as Neem formulation, Bt formulation, *Beauveria* formulation and NPV for *Helicoverpa*
- Staking of tomato plants to avoid fruit rot
- Need based use of chemical pesticides

Seed and Seedling Treatment

Seeds and seedlings were treated with *Trichoderma* and *Pseudomonas* (1:1) and shade dried for 1-1.5 hours before sowing

Insect Traps

Two way transformation processes

Training of the decision maker ultimately benefit women laborers

Green House Cultivation at IARI

BANGLADESH SYSTEMS

Positive Effect of Relay Cropping on Crop growth of Sweet Gourd

Farmer explaining the Relay Cropping of Tomato and Maize

Farmer Convinced with the Relay Cropping of Potato and Maize

Sorjan system[13]

[13] (Source: Climate Change and Food Security in Vulnerable Coastal Zones of Banglades(2015) DOI: 10.1007/978-4-431-55411-0_10 In book: Food Security and Risk Reduction in Bangladesh (pp.173-185) GOLAM Rabbani, A. Atiq Rahman, Ishtiaque Jahan Shoef Zoheb Mahmud Khan)

Floating Bed cultivation[14]

Alternate wetting and Drying (AWD)[15]

[14] (Source: Climate Change and Food Security in Vulnerable Coastal Zones of Banglades(2015) DOI: 10.1007/978-4-431-55411-0_10 In book: Food Security and Risk Reduction in Bangladesh (pp.173-185) **GOLAM Rabbani**, **A. Atiq Rahman**, **Ishtiaque Jahan Shoef** **Zoheb Mahmud Khan**)

[15] (Source: Climate Change and Food Security in Vulnerable Coastal Zones of Banglades(2015) DOI: 10.1007/978-4-431-55411-0_10 In book: Food Security and Risk Reduction in Bangladesh (pp.173-185) **GOLAM Rabbani**, **A. Atiq Rahman**, **Ishtiaque Jahan Shoef** **Zoheb Mahmud Khan**)

AFGANISTAN

Green House cultivation in Afghanistan (https://tolonews.com/business/greenhouse-farming-paying-local-farmers)

Raised bed wheat irrigation technology in Badam Bagh, Kabul. Source: USGS Survey, 2010.

Zero Energy Cool Chamber (ZECC) Low cost technology for storage of horticultural crops Source: Sayed Samiullah Hakimi, Research by Kabul University and Amity University)

Tomatoes kept in ZECC for 29 days. Source: Sayed Samiullah Hakimi, Research by Kabul University and Amity University)

Eyebrow technique of rainwater harvesting in Badam Badam, Kabul. Source: ICARDA/ARIA, Afghanistan.

Sub-surface irrigation technology used in Badam Bagh farm in irrigation of mulberry saplings. Source: ICARDA/ARIA, Afghanistan.

High density apple trees orchard of early bearing and early mature varieties in Wardak Province, Afghanistan. Source: Hakimi, S.S, 2020, Principle of Horticulture.

Rain-fed Chickpea, in Herat Province, Afghanistan. Source: AFG-ICARDA/ARIA.