

Real time implementation of agricultural contingency plans to cope with weather aberrations in Indian agriculture

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सार – पूरे वर्ष के दौरान भारत के एक अथवा अनेक भागों में मौसम के अपसरण कृषि और उसके सहायक क्षेत्रों को प्रभावित करते हैं। 21वीं सदी में मौसमी सूखा पड़ने पर और मौसम की चरम मौसम घटनाओं से न केवल कृषि उत्पादन को बल्कि बागबानी, पशुधन, मुर्गीपालन और मत्स्य उद्योग को अत्याधिक नुकसान पहुँचा है। ICAR, CRIDA, SAUS और DAC MOA GOI ने उच्चतर कृषि उत्पादन के लिए मौसम की चरम घटनाओं से निपटने के लिए आकस्मिक उपायों पर 580 से भी अधिक जिला स्तरों पर कृषि योजनाओं की सूचना तैयार की है देश में कृषि में कृषकों की खेती के लिए सूक्ष्म स्तर पर वास्तविक समय की आकस्मिक योजना आर टी सी पी की संकल्पना की गई और इसे कार्यान्वित किया गया। मॉनसून के देरी से आने, मौसमी सूखा पड़ने और बाढ़ के दौरान आर टी सी पी को कार्यान्वित करने पर बेहतर फसल निष्पादन, उच्चतर कृषि उत्पादन अच्छी आय प्राप्ति और घरेलू आजीविका के व्यापक स्थायी परिणाम प्राप्त हुए हैं। इस शोध पत्र में बागबानी की फसलों, पशुधन, मुर्गीपालन और मत्स्य उद्योगों के प्रबंधन के समय मौसम की चरम घटनाओं से निपटने के लिए वास्तविक आकस्मिक उपायों को प्रस्तुत किया गया है। इसके अलावा आर टी सी पी को कार्यान्वयन के साथ साथ नीतिगत पहल करने संबंधी तैयारियों का भी सुझाव दिया गया है।

ABSTRACT. Weather aberrations impact agriculture and allied sectors in one or other parts of the India round the year. Seasonal droughts and extreme weather events in 21st century have caused alarming losses not only in agricultural production but also horticulture, livestock, poultry and fisheries. ICAR-CRIDA, SAUs and DAC, MoA, GoI, prepared more than 580 district level agriculture plans within formation on contingency measures for sustaining higher agriculture production and to cope with extreme events. Real-time contingency planning (RTCP) is being conceptualized and implemented at micro level in farmers' fields in this country. RTCP implementation during delayed onset of monsoon, seasonal droughts and floods resulted in better crop performance, higher agricultural production, better incomes and overall stability in house-hold livelihoods. In this paper, the real-contingency measures to cope with extreme events for management of horticultural crops, livestock, poultry and fisheries are proposed. Further, the preparedness for RTCP implementation with policy initiatives is also suggested.

Key words – Climate variability, Agriculture, Real-time contingency plans.

1. Introduction

Agriculture is the mainstay of livelihood for nearly two-thirds of the population in India. The sector currently accounts for 11.6 % of the country's GDP. A major part of the agriculture in India, however, is rainfed (~77 million ha out of 142 million ha net sown area) and will remain so in the foreseeable future. The sharp fluctuations in agricultural growth are mainly attributed to the vagaries of monsoon. While one part of the country or the other experiences monsoon failure almost every year, most states do encounter droughts once in 2 to 4 years (Srinivasarao *et al.*, 2013a; 2015a). The south-west monsoon accounts for nearly 75% of the natural precipitation received in the country and therefore exerts a strong influence on *kharif* food grain production and the

economy in terms of agricultural output, farmers' income and price stability. Monsoon failures result in drought which has serious implications for small and marginal farmers and livelihoods of the rural poor.

Climate change impacts on agriculture have been witnessed in various parts of the country. Intermittent and prolonged droughts are a major cause of yield reduction in most crops. Rainfed crops are likely to be worst hit by climate change because of the limited options for coping with variability of rainfall and temperature. In 2015, the normal to heavy rainfall in the beginning of *kharif* season followed by long dry spell of 30 days and above and excess rainfall at maturity caused losses in crops such as soybean in Central India. The warming trend in India over the past 100 years (1901 to 2007) was observed

to be 0.51 °C with accelerated warming of 0.21 °C per every 10 years since 1970 (Kumar, 2009). In 2014, The hail storm events at maturity and harvest stages of *rabi* crops such as wheat, mustard and chickpea in north and north-west part of India was devastating. With a change in maximum temperature and minimum temperature impact animal productivity and health (Upadhyay *et al.*, 2009a). In poultry sector, mortality due to heat stress occurs at about 34 °C.

Agriculture in rainfed areas is essentially characterized by diverse agro-ecological and socioeconomic settings *viz.*, climates, soil types, production systems. Farmers are mostly resource poor with low adaptive capacity. Weather aberrations make rainfed agriculture highly vulnerable, risk prone and often unprofitable impacting the livelihoods of small holders. A range of administrative and technical measures are needed in dealing with droughts before they occur or when they are in progress. Several national initiatives were launched in India for climate change research and significant among them are Network Project on by the Indian Council of Agricultural Research (ICAR), National Action Plan on Climate Change (NAPCC) (2010) consisting of 8 National Missions to represent multi-pronged, long term and integrated strategies for achieving key goals in the context of climate change. The National Mission for Sustainable Agriculture (NMSA), one of the eight Missions of NAPCC, aims at devising strategies to make Indian agriculture more resilient to climate change. Furthermore, in the XI Five Year Plan, ICAR launched the National Initiative on Climate Resilient Agriculture (NICRA) in 2011 to undertake strategic research in network mode and also to demonstrate location-specific climate risk resilient technologies in farmers' fields in a participatory mode in 130 vulnerable districts spread across the country.

1.1. Real time contingency planning-concept

During 1972-73, large scale scarcity of rainfall was experienced all over the country, particularly in the scarcity region of Maharashtra, Karnataka and Andhra Pradesh. Roving seminars were organized by the ICAR at different locations, at the end of which *new phrases* were coined *viz. contingent crop planning and mid-season correction*. As a follow up, the AICRPDA (All India Coordinated Research Project for Dry land Agriculture) centres at Solapur and Bijapur (if it is AICRPDA centres) collected data on these two aspects and after analysis of weather data for the past 100 years, listed the weather aberrations: (i) delayed onset of monsoon, (ii) early withdrawal of monsoon (iii) intermittent dry spells of various durations, (iv) prolonged dry spells causing changes in the strategy and (v) prolonged monsoon (AICRPDA, 1983). Contingency plans, for each region,

was a conceptual approach unique from AICRPDA project in developing location specific contingent crop strategies which were first published in 1977 (Ravindra Chary *et al.*, 2012) and with further refinements and updating in crops and varieties, the first document was brought out by AICRPDA in 1983 on "Contingent crop production strategy in rainfed areas under different weather condition" Venkateswarlu *et al.*, 1983). The AICRPDA network centers developed crop contingency plans for each centre's domain (Subba Reddy *et al.*, 2008; Ravindra Chary *et al.*, 2012). Further, during 2009-10, AICRPDA centres prepared contingency measures considering weather aberrations, seasons, and the predominant *kharif* and *rabi* crops with appropriate crop management strategies. Central Research Institute for Dry land Agriculture (CRIDA) with information available at AICRPDA centres and SAUs, prepared district level agriculture contingency plans for more than 580 districts in collaboration with Department of Agriculture and Cooperation (DAC), Ministry of Agriculture, GoI, ICAR institutes, State Agricultural/Horticultural/Animal Science/Veterinary/Fisheries Universities, Krishi Vigyan Kendras (KVKs), and the State line departments. These plans essentially suggest coping strategies/measures in agriculture, horticulture, livestock, fisheries and poultry sectors in the event of delayed onset of monsoon, seasonal drought, unseasonal rainfall events, floods, cyclones, hail storm, heat/cold wave (Srinivasarao *et al.*, 2015a; Venkateswarlu *et al.*, 2011; Prasad *et al.*, 2013).

In view of the frequent weather aberrations round the year in one or the other part of the country impacting agricultural production, to minimize the losses in agriculture and allied sectors and to improve the efficiency of the production systems, the need was felt to implement contingency measures on real-time basis. Thus, Real Time Contingency Planning is considered as "Any contingency measure, either technology related (land, soil, water, crop) or institutional and policy based, which is implemented based on real time weather pattern (including extreme events) in any crop growing season" (Srinivasarao *et al.*, 2013).

2. RTCP-Methodology and institutions

The approach was to saturate whole village with the climate resilient technologies. The interventions which require high investment like farm ponds were planned for few suitable locations in the village. *In situ* moisture conservation and other improved agronomic practices such as inter-cropping and new varieties were demonstrated in a contiguous area in the village. In selecting the beneficiaries, the farmers' most vulnerable to climatic variability and the smallholders were given priority. It was also ensured that the village has control

farm/plot/animals for all the implemented interventions in order to assess the impact of interventions in a short period. The action plans were prepared for each village with details of activities along with roles and responsibilities of stakeholders, period and budget for each intervention. The real-time contingency measures aim to (i) to establish a crop with optimum plant population during the delayed onset of monsoon; (ii) to ensure better performance of crops during seasonal drought (early/mid and terminal drought) and extreme events, enhance performance, improve productivity and income; (iii) to minimize damage to horticultural crops/produce; (iv) to minimize physical damage to livestock, poultry and fisheries sector and ensure better performance) to ensure food security at village level and (vi) to enhance the adaptive capacity and livelihoods of the farmers.

Some of the methods/measures to be adopted as real-time contingency plan implementation during various weather aberrations are presented below:

2.1. *RTCP measures for various climatic aberrations in arable crops*

<i>Climatic aberration</i>	<i>RTCP measures</i>
Delayed Onset of monsoon	<ul style="list-style-type: none"> 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.
Early season drought	<ul style="list-style-type: none"> Resowing within a week to 10 days with subsequent rains for better plant stand when germination is less than 30%. Thinning in small-seeded crops. Interculture to break soil crust and remove weeds and create soil mulch for conserving soil moisture. Avoid top dressing of fertilizers till favourable soil moisture. Opening conservation furrows at 10 to 15m intervals. Ridge and furrow across the slope for effective moisture conservation as well in as rainwater in wide spaced crops (>30 cm). Pot watering along with gap filling when the crop stand is less than 75% in crops like cotton.

- Foliar spray of 2% urea during prolonged dry spells wherever ground/surface water is available.
 - Plant protection.
 - Supplemental/protective irrigation, if available.
 - Repeated interculture to remove weeds and create soil mulch to conserve soil moisture.
 - Avoid top-dressing of fertilizers until receipt of rains.
 - Opening conservation furrows for moisture conservation, Foliar spray of 2% KNO₃ or 2% urea solution or 1% water soluble fertilizers like 19-19-19, 20-20-20, 21-21-21.
 - Opening of alternate furrows.
 - Surface mulching with crop residues.
- Mid-season drought
- Providing life-saving or supplemental irrigation, if available, Harvesting crop at physiological maturity with some realizable yield or harvest for fodder.
 - Prepare for winter (*rabi*) sowing in double- cropped areas.
 - Ratoon maize or pearl millet or adopt relay crops as chickpea, safflower, *rabi* sorghum and sunflower with minimum tillage after soybean in medium to deep black soils in Maharashtra.
 - Prefer contingency crops (horsegram/ cowpea) or dual-purpose forage crops on receipt of showers under receding soil moisture conditions.
- Terminal drought
- Re-sowing.
 - Providing surface drainage.
 - Application of hormones/nutrient sprays to prevent flower drop or promote quick flowering/fruitletting and plant-protection measures against pest/disease outbreaks with need based prophylactic/curative interventions.
 - At crop maturity stage, prevention of seed germination and harvesting of produce.
 - If untimely rains occur at vegetative stage, the contingency measures include:
- Unseasonal heavy rainfall events

- Draining out the excess water as early as possible.
 - Application of 20 kg N + 10 kg K/acre (0.4 ha) after draining excess water.
 - Application of 50 kg urea+ 50 kg murate of potash (MOP)/acre (0.4 ha) after draining excess water.
 - Gap filling either with available nursery or by splitting the tillers from the surviving hills in rice.
 - Weed control.
 - Suitable plant protection measures in anticipation of pest and disease out breaks.
 - Foliar spray with 1%KNO₃ or water-soluble fertilizers like 19-19-19, 20-20-20, 21-21-21 at 1% to support nutrition.
 - Need-based fungicidal spray with Copper oxychloride 0.3% or Carbendazim 0.1% or Mancozeb 0.25% 2 to 3 times by rotating the chemicals.
 - Interculture at optimum soil-moisture condition to loosen and aerate the soil and to control weeds.
 - Earthing up the crop for anchorage etc.
- Floods
- In sand-deposited crop fields/fallows, ameliorative measures include early removal or ploughing in of sand (depending on the extent of deposit) for facilitating *rabi* crop or next *khari*.
 - In silt-deposited Indo-Gangetic Plains, early *rabi* crop plan is suggested in current cropped areas and current fallow lands.
 - Draining out of stagnant water and strengthening of field bunds etc.
 - In *diara* (flood prone)land areas, measures include alternate crop plans for receding situations.
 - Community nursery raising.
 - Re-transplanting in damaged fields and transplanting new areas or direct seeding depending on seed availability.
- Prevention of pre-mature germination of submerged crop at maturity or of harvested produce by spray of salt solution.
- Heat wave
- Light frequent irrigation.
 - Foliar spray with thiourea or KNO₃ at recommended dose.
- Cold wave
- Light frequent irrigation during evening hours.
 - Basin mulching.
 - Smoking during night.
 - Application of supplemental fertilizer dose.
- Frost
- Change in planting time to avoid sensitive stages coinciding with frost period.
 - Thatching young plants.
 - Mulching ground cover to prevent loss of heat.
- Hailstorm
- Use of anti-hail guns and anti-hail nets. Spray 0.1% Carbendazim to control secondary fungal infection.
 - Open trenches to drain out excess water from the field; apply Dithane M-45 @ 0.2% on ear heads immediately after cessation of rains.
- If crop at harvesting stage, harvest mature cobs immediately and dry to avoid fungal growth.
 - Store the cob and fodder after proper drying for 4-5 days.
 - Foliar spray with sulphur @25 g/10 litre water may be carried out to prevent its incidence.
 - Spray with Carbendazim @0.1% immediately after cessation of rains to protect against boll rot.
- Cyclones
- Providing field drainage, staking and propping of plantation crops.
 - Cleaning and drying of harvested field crops.
- Source* : Venkateswarlu *et al.*, 2011; Srinivasa *et al.*, 2015 b ; Umate *et al.*, 2011.

2.2. RTCP measures for various climatic aberrations in Horticulture crops

Climatic aberration	Horticulture crops	RTCP measures
Heat wave	Mango, pear, guava, citrus, litchi	<ul style="list-style-type: none"> • Provide irrigation, if available. • Provide shade with wild bushes.
Cold wave	Mango, litchi, pear, guava	<ul style="list-style-type: none"> • Light frequent irrigation. • Mulching. • Thatching and creating smoke screens and lighting of fire where irrigation facilities are not available.
Frost	Orange (Mandarin and sweet orange)	<ul style="list-style-type: none"> • At vegetative stage, prune damaged branched and twigs and apply Bordeaux paste 1% to avoid fungal infection. • At reproductive stage, apply hormonal spray NAA 20 ppm + 1% urea to prevent flower drop.
	Mango, litchi, pear, guava	<ul style="list-style-type: none"> • Light frequent irrigation. • Mulching. • Thatching and creating smoke screens and lighting of fire.
Hailstorm	Mango	<ul style="list-style-type: none"> • Spray potassium nitrate @ 1% to arrest flower and fruit drop. • If cloudy conditions persist after the hail occurrence, orchards may be sprayed with fipronil (5% EC) @ 1.5 ml/litre or Spinosad (45% SC) @ 0.3 ml/litre to control hoppers and thrips and Hexaconazole @ 1 ml/litre to control powdery mildew disease. • Prefer anti hail nets at seeding, flowering and fruit bearing stage.

Banana	<ul style="list-style-type: none"> • At the time of damage, if the fruit branch is beyond three quarters maturity, harvest and market it as soon as possible. • At other stages, prune severely damaged leaves up to base of petiole. • Apply booster dose of urea and MOP to partially damaged orchards. • Spray potassium sulphate (5g/litre water) and urea (10g/litre water) solution on plants with newly emerged fruit bunches. • Spray mancozeb @ 2.5 g/litre or Carbendazim @ 1.0 g/litre of water on leaves and pseudo-stems and developing fruits to avoid secondary infection. 	
Floods	Mango	<ul style="list-style-type: none"> • Drain the excess water from the orchard. • Spray urea 2% solution for 2-3 times at 7-10 days interval. • Ensure proper drainage at least once in two days as all horticultural crops are sensitive to continuous submergence. • Transplanting in new areas. • Strengthen field bunds.
	Banana	<ul style="list-style-type: none"> • Open deep trenches between plant rows to improve drainage. • Foliar spray of 2% K₂SO₄ after 15 days another spray of 1% K₂SO₄. • Spray Dithane M-45 3 g/litre or Propiconazole 1ml/liter 2-3 times against <i>cercospora</i> leaf spot.

		2.3. RTCP measures for climatic aberrations in Livestock sector	
		Climatic aberration	RTCP measures
Cyclones	Mango	<ul style="list-style-type: none"> • If the damage is severe, prefer replanting. • Propping and earthing up of damaged and fallen trees. • Manuring in the basin. • Broken and damaged branched may be pruned and applied with 1% Bordeaux paste. • Collect the fallen fruits and grade for good quality and marketing and go for preparation of processed products. 	<ul style="list-style-type: none"> • Use biomass of dried up crops as fodder. • Prefer azolla and silage as supplement for milch animal. • Enrich hay with 2% Urea molasses solution or 1% common salt solution and fed to livestock. • Cull out unproductive livestock. • For drinking water, ensure adequate supply of drinking water, restrict wallowing of animals in water bodies/resources. • Carryout de-worming to all animals entering into relief camps. • Identify and quarantine sick animals, perform ring vaccination (8 km radius) in case of any outbreak.
	Banana	<ul style="list-style-type: none"> • Proper propping and bamboo or casuriana poles to avoid lodging. • Wind damaged plant should be pruned using disinfected secateurs and cut ends must be smeared with 1% Bordeaux paste. 	
	Mango	<ul style="list-style-type: none"> • At flowering stage: <ul style="list-style-type: none"> ○ Spray hormones or multi nutrients to promote flowering and fruit set. ○ Prefer supplementing pollination techniques to improve pollination and fruit set. ○ Protect from strong winds specially during flowering and fruiting stage by growing wind breaker trees around the orchard. ○ 2% potassium nitrate at full bloom improves fruit set and fruit retention. 	
		Drought	<ul style="list-style-type: none"> • Use biomass of dried up crops as fodder. • Prefer azolla and silage as supplement for milch animal. • Enrich hay with 2% Urea molasses solution or 1% common salt solution and fed to livestock. • Cull out unproductive livestock. • For drinking water, ensure adequate supply of drinking water, restrict wallowing of animals in water bodies/resources. • Carryout de-worming to all animals entering into relief camps. • Identify and quarantine sick animals, perform ring vaccination (8 km radius) in case of any outbreak.
		Floods and cyclones	<ul style="list-style-type: none"> • In case of early forewarning (EFW), harvest all the crops that can be useful as feed or fodder in future and properly stored from inundation by flood waters. • Sufficient dry fodder is to be transported to the flood affected villages to meet the fodder requirements. • Apply urea (20-25 kg/ha) in the inundated areas and CPRs to enhance the biomass production.
		Heat wave	<ul style="list-style-type: none"> • Allow animals preferably early in the morning or late in the evening for grazing, in severe cases, vitamin 'C' (5-10ml per litre) and electrolytes (Electral powder @ 20g per litre) should be added in water.
		Cold wave	<ul style="list-style-type: none"> • Allow for grazing between 10 AM to 3 PM. • Arrange heaters in case of high productive animals add 25-50 ml of edible oil in concentrates and fed to the animal. • Apply / sprinkle lime powder in the animal shed during cold waves to neutralize ammonia accumulation.

Source : Venkateswarlu *et al.*, 2011; Umate *et al.*, 2011; Rao *et al.*, 2014)

Source : Venkateswarlu *et al.*, 2011; Umate *et al.*, 2011

2.4. *RTCP measures for various climatic aberrations in Poultry sector*

Climatic variability	RTCP measures
Drought	<ul style="list-style-type: none"> • Arrange feed supplementation only for productive birds with household grain and shell grit (calcium) for laying birds. • Culling of weak birds. • Prefer water sanitizers or offer cool hygienic drinking water; mixing of Vit. A. D. E. K. and B-complex including vit C in drinking water (5 ml in one liter water).
Flood/cyclones	<ul style="list-style-type: none"> • Proper care or shelter. • Timely health care. • Prevent water logging surrounding the sheds through proper drainage facility. • Sprinkle lime powder to prevent ammonia accumulation due to dampness culling out affected birds.
Heat wave	<ul style="list-style-type: none"> • Use stored fed as supplement. • Don't allow for scavenging; culling of weak birds. • Prefer water sanitizers or offer cool hygienic drinking water. • Ensure supply of electricity by generator or solar energy or biogas.

Source : Venkateswarlu *et al.*, 2011; Umate *et al.*, 2011

2.5. *RTCP Measures for various climatic aberrations in Fisheries sector*

Climatic variability	RTCP measures
Drought	<ul style="list-style-type: none"> • For inland fisheries, prefer immediate harvesting or decreasing the density commensurate with the water quantity and application of sanitizers. • For aqua culture, harvesting of fish and leaving the pond fallow till next season. • Frequent change of water with fresh water.
Cold wave	<ul style="list-style-type: none"> • In aquaculture, avoid fishing.

Source : Venkateswarlu *et al.*, 2011; Umate *et al.*, 2011

3. **Field level impacts of real-time contingency implementation-experiences from AICRPDA**

The 23 Network centres of All India Coordinated Research Project for Dry land Agriculture adopted 34 villages across diverse agro ecologies (rainfall, soil types and production systems) under the Technology demonstration component of NICRA to demonstrate land, water, crop, soil, nutrient and energy (farm implements) management practices on real-time basis to cope with weather aberrations. The major components for real-time contingency plan implementation for improving agriculture production to cope with weather aberrations were: rainwater management (*in-situ* and *ex-situ*) crop, variety, cropping systems and crop diversification, nutrient management, energy management and alternate land use. During 2011 to 2014, the real-time contingency measures were implemented in the selected 34 villages to cope with various weather aberrations and enhance agricultural production at field level and the impacts are presented briefly below (Srinivasarao *et al.*, 2013; 2015b):

3.1. *Delayed onset of monsoon*

Under delayed onset of monsoon, the RTCP interventions such as s introduction of short duration variety, opening conservation furrows, sowing on ridge and furrow system enhanced moisture use efficiency and crop yields. The impact of real-time contingency measures under delayed onset of monsoon is presented in Table 1.

3.2. *Early season drought*

During early season drought, RTCP interventions such as supplemental irrigation and opening of conservation in the standing crops enhanced crop productivity. The impacts of real-time contingency measures under early season drought are presented in Table 2.

3.3. *Mid-season drought*

During midseason drought, implementation of RTCP measures such as opening conservation furrow, foliar sprays with chemicals and supplemental irrigation during dry spells increased crop yields. The impacts of real-time contingency measures during midseason drought are presented in Table 3.

3.4. *Flash flood*

In north bank plain zone of Assam, under delayed transplanting condition due to occurrence of intermittent flash floods, introduction of flood tolerant varieties such as Gitesh performed better during flash floods compared

TABLE 1

Impact of real-time contingency measures under delayed onset of monsoon conditions in different states

District (State)	Crop	Contingency measure	Impact of Interventions		
			Yield (kg/ha)		B:C ratio with RTCP
			With RTCP	Without RTCP	
Kandhamal (Odisha)	Rice	Drought tolerant variety -Vandana	2034	1500	1.46
Bangalore (Karnataka)	Fingermillet (MR-1)	Transplanted after 21 DAS	2623	2172 (Direct)	2.46
Rajkot (Gujarat)	Groundnut (GG20)	Ridge and furrow system	1186	1144	1.05
Arjia (Rajasthan)	Maize (PM3)	Ridge and furrow system	2667	2250	3.75
Hoshiarpur (Punjab)	Maize (JH-3459)	<i>In-situ</i> moisture conservation (sowing across slope)	3148	2963	2.19
Hoshiarpur (Punjab)	Pearlmillet	Drought tolerant variety - FBC-16)	4300	3400	2.89

(Source : Srinivasarao *et al.*, 2013b; AICRPDA-NICRA-Annual Reports-2011-12; 2012-13; 2013-14)

TABLE 2

Impact of real-time contingency measures during early season drought in rainfed regions of India

District (State)	Crop	RTCP measure	Impact of Intervention			
			Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio With RTCP
			With RTCP	Without RTCP		
Lakhimpur (Assam)	Potato (Kufri Pokhraj)	Supplementary irrigation of 9.4 cm during stolon formation & tuber growth stages	26750	12100	109475	Up to 3.87
Bangalore Rural (Karnataka)	Fingermillet + pigeonpea (8:2) IC	Conservation furrow 35 days after sowing	3861	-	31534	3.10
Kurnool (A.P.)	Groundnut	Conservation furrow	462	396	3591	1.20
Kurnool (A.P.)	Cotton (Bijadhan BG II)	Critical irrigation 5cm	3475	2850	28125	1.24

(Source : Srinivasarao *et al.*, 2013 b; AICRPDA-NICRA-Annual Reports-2011-12; 2012-13; 2013-14)

TABLE 3

Impact of real-time contingency measures during midseason drought in major rainfed states of India

District (State)	Crop	RTCP measure	Impact of Intervention			
			Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio with RTCP
			With RTCP	Without RTCP		
Akola (Maharashtra)	Cotton (NCS)	Opening conservation furrow across the slope at 30 DAS	1250	1188	-	1.86
Rajasmand (Rajasthan)	Maize (PM-3)+ blackgram (T9) (2:2)	Supplemental irrigation of 7 cm at reproductive stage of maize	2670	2380	3265	3.07
Indore (MP)	Soybean (JS-95-60)	Foliar spray with Mo @0.1% in 2 sprays	412	399	27313	2.03
Rajkot (Gujarat)	Castor (GCH-7)	Supplemental irrigation through drip system	2750	2300	70150	2.02
	Cotton	Foliar spray with potassium nitrate @ 2% at square formation & boll development stage	2646	2124	88650	2011

(Source : Srinivasarao *et al.*, 2013 b; 2015b; AICRPDA-NICRA-Annual Reports-2011-12; 2012-13; 2013-14)

TABLE 4
Performance of flood tolerant rice varieties in Eastern and North Eastern India

Location	RTCP measure	Yield (kg/ha)		B:C ratio with RTCP
		With RTCP	Without RTCP	
Assam	Flood tolerant rice varieties- Gitesh	3102	2300	1.90
Gujarat, Chhattisgarh, Western Tripura	Flood tolerant rice variety - MTU-1010	3400	2677	1.98
Odisha, Chhattisgarh	Flood tolerant rice variety - MTU-1061	3700	2624	1.75
West Bengal, Maharashtra, UP, Assam and North central AP	Flood tolerant rice variety - Swarna sub-1, Indira	4400	3142	-

(Source : Prasad *et al.*, 2014 and Srinivasarao *et al.*, 2013 b)

TABLE 5
Additional income benefits expected through RTCP's implementation in larger area in different Indian states

State	AICRPDA Domain Districts	Crop	Weather aberration	Intervention	Income in Crores / one lakh ha
Karnataka	Bangalore Rural	Fingermillet	Delayed on set of monsoon	Drought tolerant GPU 28 medium duration variety	211.61
Assam	Lakhimpur	Rainfed Rice	Flash flood	Flood tolerant variety - Jalashree	114.00
Rajasthan	Bhilwara	Groundnut	Delayed onset of monsoon	Drought tolerant variety - TG-37A	889.55
Andhra Pradesh	Kurnool	Groundnut (K-6)	Delayed onset of monsoon (9 Days)	Water Spray during dry spell flowering, pegging and pod development stages	762.50

(Source : AICRPDA-NICRA-Annual Reports-2011-12; 2012-13; 2013-14; Srinivasarao *et al.*, 2013b)

to popular varieties like Ranjit. There was 100% increase in the yield of Gitesh as compared to the local cultivars (Gitesh - 3102 kg/ha; B: C ratio of 1.90). During 2012, the flash floods occurred for a period of 32 days *viz.*, 23rd June to 8th October (7 days) during 2012 and 36 days during, 2013 *i.e.*, 18th to July 8th September. The rice crop experienced to intermittent flash floods for 4 times during the season. Introduction of submergence tolerant varieties of rice *viz.*, Jalashree and draining of excess water from field which resulted in better *Sali* rice. All other varieties of rice including *Jalkunwari* were affected but Jalashree performed better. With Jalashree, the grain yield of 900 kg/ha and net returns of Rs.11,400/ha were obtained while the local varieties failed. Though the yield of Jalashree was very low (as compared to normal year), still there was 100% benefit to the farmers compared to local varieties. The impact of RTCP interventions such as introduction of flood tolerant varieties in rice crops in various regions of the country is given in Table 4.

4. Economic Impacts if adopted in larger area

The real-time contingency plans, if implemented in one lakh ha, there is a scope for higher additional income benefits to the farmers (Table 5).

5. Preparedness for RTCP Implementation during Drought

The drought risk management may consist of four stages: preparedness, mitigation, relief and rehabilitation (Fig. 1). For RTCP implementation during drought, initial preparedness is prerequisite. Depending upon past weather data and experience, preparedness to implement RTCP measures is necessary to address late onset of monsoon, early, mid-season and terminal droughts. For this, village level institutions play greater role to provide inputs such as suitable seed, fertilizers, and need based farm implements during crop growing season. A combination

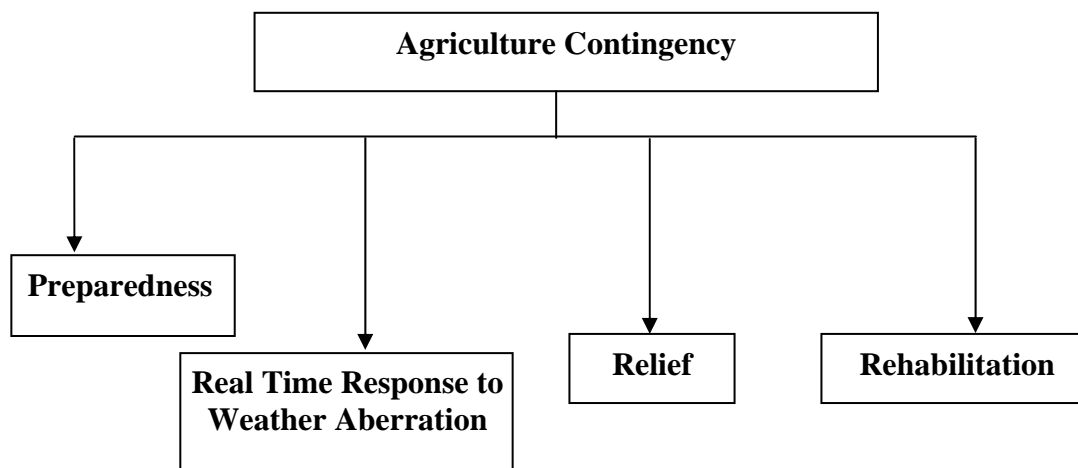


Fig. 1. Initial Preparedness for drought - For implementation of real time contingency planning (Source : Srinivasarao *et al.*, 2013; 2015b)

of tolerant crop/system, cultivar, soil and nutrient management should be of integral part of the overall Agricultural Contingency Plan. To facilitate these interventions, suitable farm implements inputs and need based fodder systems are essential. Various components of “Preparedness”, such as “*Must Do Practices*”, need to be a part of RTCP implementation. Similarly stress tolerant seed availability in village seed banks, required nutrients in nutrient bank along with farm machines will contribute to timely completion of sowing operation particularly when the sowing window is limited, as is the case with most of the regions.

5.1. Role of institutions

A consortium of research organizations, farmer groups, agricultural extension officers, KVKs, line departments, district officials need to be formed to implement real time contingencies at farm level. Collective action may lead to reducing the negative impacts of weather aberrations. The Village Level Institutions (VLIs) provide ownership of any development project by making them an integral part of decision-making, giving them control over their resources, autonomy to implement the project, and carry on the process even after the completion of such projects. The VLIs such as Village Climate Risk Management Committee (VCRMC), *Salaha Samithi*, commodity groups, Custom Hiring Centre Management Committees (CHCMC), farmers groups for managing seed banks, fodder banks, Collective Marketing Group and nutrient banks play a greater role in RTCP implementation. CRIDA, in many on station/on farm programme through projects/ such as NATP, NAIP, DFID, NICRA ORPs etc. innovated many VLIs and successfully demonstrated bringing sustainability in productivity rainfed production system.

5.2. Government programmes and convergence needs

Farm production adaptations include farm-level decisions with respect to farm production, land use, land topography, irrigation, and the timing of operations. Changing or modifying the farm activities have the potential to reduce exposure to climate-related risks. Government schemes such as National Mission on Sustainable Agriculture (NMSA), MGNREGA, RKVY (Rashtriya Krishi Vikas Yojana), Mega Seed Project, NFSM (National Food Security Mission), NHM (National Horticulture Mission), Soil Health Schemes, Farm Machinery and Implements etc provide an opportunity to respond to different kind of weather aberrations as contingencies on real time basis. Rainwater management interventions like water harvesting and storage structures are capital and labour intensive thus, can be converged with NMSA, RKVY, MGNREGA, NHM and IWMP programmes. Further in situ moisture conservation interventions which are land based activities can be converged with MGNREGA and DRDA (District Rural Development Agency) programmes in a district. Efficient utilization of stored rainwater in farm ponds with micro-irrigation systems like drip and sprinkler could be converged with government schemes like Micro-irrigation Project in Andhra Pradesh, NHM and SHM (State Horticulture Mission), Government schemes etc. (Srinivasarao *et al.*, 2014; 2015a).

5.3. Policy needs

Implementation of agriculture contingencies on real time basis needs a stronger polity support. In India, as an alternative to the existing Area-Yield based National Agricultural Insurance Scheme, the Weather Based Crop

Insurance Scheme was launched as a pilot in 2007 with the objective of mitigating the hardship of the insured farmers against the possibility of financial loss associated with low crop yields or crop failure resulting from adverse weather conditions. The scheme is a publicly subsidized - index based insurance scheme. In view of recent extreme events such as excess rainfall and hailstorm in many parts of the country indicates a relook in to this policy as a safety net to large section of farmers. In many rainfed regions, often the window for crop sowing is limited, and ensuring farm implement availability in the village to complete sowing of crops becomes important. Therefore, a comprehensive policy is needed for operationalization of Custom Hiring Centres on large scale on a sustainable basis. Strong implementable interventions are needed to ensure the purchase of damaged grain at local level. Availability of seed material of contingent crops such as legumes, millets and oil seed crops need to be ensured. A policy at national level is necessary for maintaining the seed for timely supply during delayed onset of monsoon or early season drought and further, in case of normal season, the seed maintained may be procured through public distribution system. Agriculture related to policies such as disaster management, land and water, food security etc. should be synergistically converged at the grass root level, so that system becomes more climate resilient.

6. Conclusions

Technology development in agriculture should address weather aberrations, which will make agriculture production more climate resilient. Adaptation to climate change in agriculture comes from a various approaches, particularly research that considers geographic scales *viz.*, plant, plot, field, farm, region, sector, nation and international. At the same time, responsibility for implementation of RTCPs can be differentiated among the various stakeholders that undertake or facilitate adaptations in agriculture including individual producers (farmers), agri-business (private industries), and governments (public agencies). To strengthen implementation of real time contingency plans various options are available and the most important options include technological developments, convergence with government schemes and policy interventions. Technological adaptations are developed through research programs undertaken or sponsored by public and or private sector. The technological adaptation options could be crop development (to increase their tolerance); weather and climate information systems (to provide forecasts); and natural resource management such as water, land, soil factors (to deal with of climate-related risks).

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