Draft

Drought Management Strategies – 2009

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New Delhi

Contents

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1. Introduction

Rainfall is the ultimate source of water, affecting production of crops and other biomass by direct falling on the fields as well as supporting surface and ground water irrigation. However, possibilities of drought occurrence in India vary from once in 2 years in Western Rajasthan to once in 15 years in Assam. The frequency and intensity of extreme weather events like droughts, floods, heat/cold waves, cyclones, delayed or early onset, long dry spells, early withdrawal, floods in drought frequented areas and droughts in flood afflicted areas have increased during the last two decades due to global warming.

The Indian sub-continent is predominantly characterized by a tropical monsoon climate and entire regime is distinguished mainly by the differences in rainfall both in quantity and distribution. The most important feature is the regional and temporal alteration of atmospheric flow patterns associated with monsoon. There are two monsoon systems operating in the region (a) the southwest or summer monsoon and (b) the northeast or the winter monsoon. The summer monsoon accounts for 70 to 80% of the annual rainfall over major parts of south Asia. There is a large variability in the monsoon rainfall on both space and time scales. Consequently the Indian regions experience drought or flood in some parts of the country or the other almost every year during the monsoon period between June-September. Out of 44 (1965-2009) years, Orissa witnessed droughts in 19 years, floods for 17 years and cyclones for 7 years. In the past, India has experienced twenty two large scale droughts in 1891, 1896, 1899, 1905, 1911, 1915, 1918, 1920, 1941, 1951, 1965, 1966, 1972, 1974, 1979, 1982, 1986, 1987, 1988, 1999, 2000 and 2002 with increasing frequencies during the periods 1891-1920, 1965-1990 and 1999-2002.

Droughts in the Indian region are mainly due to various kinds of failures of rains from southwest monsoon. Also there seems to be some association between El Nino and La Nina events and weak monsoons. Over more than hundred years period between 1871-1988, 11 of the 21 drought years were El Nino years. During the 90 years period between 1901-1990 rainfall was sufficient in all 7 strong El Nino cases. The El Nino phase of the Southern Oscillations (ENSO) has direct impact on drought in India which causes weak or enhanced summer monsoon.

2. Benchmarks of Normal Monsoon Behaviour and Possible Shifts

i) South-west monsoon over different parts of the country sets in at different times between May and September. Its normal onset period over Kerala is around 29th May and by June 1st week, the northern limit of monsoon passes over Karnataka, Manipur and Tripura. By the second week of June, the limit passes through Mumbai, Kolkata and covers the states of Assam and Arunachal Pradesh.

ii) The onset over the north-western parts of India is around last week of June to the first week of July and covers the entire country within about 30 days. Similarly, monsoon withdrawal starts from the second week of September over the northern parts and around 15th October, the south-west monsoon conditions cease to operate.

iii) Breaks in monsoon situations result from the change in the track of tropical depressions from Bay of Bengal and their number in a given month give rise to dry spells over certain sub-divisions in any given year. It happened in 2009 due to cyclone called Aila.

iv) The four broad scenarios for which one has to plan for contingency are:

I. Delayed onset	Maximum of three weeks from normal date for the given region. This happened in North-west India in 2002 and North West and North East India in 2009.
II. Early onset and sudden breaks.	This scenario happened in some parts of the country in 2009.
III. Early withdrawal of monsoon	By last week of August and causes stress during maturity of crops.
IV. Delayed withdrawal or extended monsoon.	May damage matured crops at the harvesting time.
V. Various permutations and combinations of above four scenario.	Complexities of management increases.

3. Facts about Drought

i) Since drought is defined by deviation from the normal rainfall, it can happen in all rainfall regions. It also occurs in high rainfall area but severity or frequency may vary.

ii) Assessment and management of drought is complex due to its gradual appearance and long lasting impact or recoveries.

iii) Characteristics and impact of drought vary from region to region and year to year.

iv) Drought affects human, livestock, wildlife, bio-diversity and degrades the quality of natural resource base.

v) Drought management strategies in the past were adopted generally during or after the onset of drought and lacked pro-active preventive interventions during normal or excessive rainfall years.

4. Drought Policy

Desirable features of drought weather codes of a sustainable framework are:

(i) Reliability of early warning systems for drought is a complex phenomenon and requires upgradation.

(ii) Creation of data bank for scenario of human, livestock, water resources, food/fodder supplies, natural resources etc. for major droughts in the past. Analysis of this information and experience should provide sound basis for future planning.

(iii) Billions of rupees are spent for drought mitigation in most of the years. This expenditure should lead significantly towards drought adaptations, mitigation/moderation and reduce vulnerability (poverty) in the future. This may require paradigm shift in the planning and implementation process.

(iv) Perennial component of vegetation may be expanded to improve resilience or robustness.

(v) Concept of farming system approach involving social capital of humans, livestock and other subsidiary income generating activities.

(vi) Utilizing potential of industrial and cash crops such as medicinal, oil yielding adapted to drought conditions to expand income and employment generating options.

5. Probability of Occurrence of Drought

Based on the analysis of long series of yearly data, probability of occurrence of drought in different meteorological sub-divisions is given in table 1.

Table 1. Probability of occurrence of drought in different meteorological sub-divisions of India

Meteorological sub-division	Frequency of deficient rainfall (75% of normal or less)
Assam	Very rare, once in 15 years
West Bengal, Madhya Pradesh, Konkan, Bihar and Orrisa	Once in 5 years
South interior, Karnataka, Eastern Uttar Pradesh & Vidarbha	Once in 4 years
Gujarat, East Rajasthan, Western Uttar Pradesh	Once in 3 years
Tamil Nadu, Jammu & Kashmir and Telengana	Once in 2.5 years
West Rajasthan	Once in 2 years

6. Past Initiatives to Combat Drought

The governmental strategy generally focussed on empirical measures of employment generation through relief works, cattle camps, fodder depots, animal healthcare, subsidized cattle feed for the milch cattle, drinking water arrangements, augmenting existing or creation of new sources, medical and health arrangements. At the same time, the state governments ensured effective implementation of centrally sponsored schemes like the Mid-Day Meal Scheme, Public Distribution System of food grains etc.

The central government has permanent budgetary arrangements of Calamity Relief Fund (CRF) and National Calamity Contingency Funds (NCCF), for reducing the impact and severity of droughts. Some of the other sponsored programmes included: Rural Works Programme, Drought Prone Area Programme (DPAP), Desert Development Programme (DDP), Food for Work Programme, Integrated Watershed Management Programmes etc.

7. Establishment of Crop-Weather Watch Group

During 1979 drought, the Ministry of Agriculture set up a watch group consisting of representatives from the Department of Agriculture, India Meteorological Department (IMD), Indian Council of Agricultural Research (ICAR), Ministry of Information and Broadcasting and others. A two pronged strategy was adopted which focussed on curative and preventive measures. They were to provide weekly reports of rainfall, agricultural operations, market prices, employment and other activities during drought period. The twelve point program was created to avert Trikal (*Akal, Jalkal, Tinka*), which means to take care of food, water and fodder to avoid starvation deaths. Various components of the twelve-point program that provided relief were: (i) full-time relief officers; (ii) proper monitoring; (iii) availability of food grains; (iv) opening of fair price shops; (v) curtailing activities of anti-social elements; (vi) food for work program; (vii) food for nutrition; (viii) contingency planning; (ix) public health safety measures; (x) boring wells for drinking water, and (xi) cattle camps and relief measures.

8. International Efforts

UN Convention to Combat Desertification (UNCCD) in countries experiencing serious drought and/or desertification has been established as a nodal agency to coordinate drought/desertification and mitigation strategies in different countries of the world. The main objective of this convention is to combat desertification and poverty alleviation in countries facing serious drought and/or desertification through an effective International Cooperation and Partnership Arrangements in the frame work of an integrated approach consistent with Agenda 21 of the Rio Conference. Achieving this objective will involve long-term integrated strategies that focus simultaneously on improved productivity of land and water resources leading to enhanced living conditions, in particular at the community level. The convention as is the case with the Agenda 21, emphasizes general principles, institutions, policies and processes covering following:

(i) Integrating environmental and developmental goals for cross-sectoral planning.

(ii) Cross-sectoral planning at national level called the National Action Plan of the country.

(iii) Participatory and decentralized approaches to planning and implementation.

(iv) Building institutional and human capacity.

(v) Information exchange and networking.

9. Feed Back from Past Drought Mitigation Efforts

There was hardly any sustained medium and long range policy or strategy prior to 2002. Temporary measures in the form of relief were adopted during the calamity whereas mitigation or moderation has to be designed during normal or excessive rainfall years.

(i) Lack of integrated planning was considered a major constraint in achieving the objectives. Most activities were planned and executed on a sectoral basis e.g. animal husbandry, agriculture, soil and water conservation etc. independent of each other. This lacked synergy in achieving the expected benefits.

(ii) Non-participation of local communities from beginning either in preparation of plans or in their execution. As a result, the program did not have backing of vast indigenous knowledge possessed by the communities in terms of adaptations.

(iii) Non-integration of works with developmental planning. The drought prone areas relief works were rarely integrated with area development plans designed to conserve soil and rain water and to generate other income earning opportunities on a sustained basis which could mitigate the adverse effects of droughts on a lasting basis.

(iv) Non-availability of accurate and reliable spatial and temporal data was a fundamental bottleneck. For example, provision of free/subsidized electricity lowered ground water in excess of its annual replenishment.

10. Early Warning and Forecasting of Drought

Drought in the Indian region can be monitored from the progress of onset and withdrawal of southwest monsoon. Weather forecasts broadly can be classified into three categories viz., (i) short range forecast (validity for less than 3 days), (ii) medium range forecast (validity from 3-10 days period), and (iii) long range forecast (validity for more than 10 days). These forecasts are issued by the India Meteorological Department through All India Radio, Doordarshan, private channels and various Newspapers. The National Centre for Medium Range Weather Forecast in the department of Science and Technology disseminates weather related information through its network of 82 Agro-met Advisory Service (AAS) units located mainly in State Agricultural Universities and ICAR institutes. The ICAR funded All India Coordinated Research Project on Agro-meteorology is operative at 22 centres in the country. The main objectives of this project are: characterization of climate, crop-weather relations,

crop weather modelling, weather related forewarning of incidence of diseases and pests and agro advisory service to the farmers. Some private companies are also collecting and trading weather information to bankers, insurance and forward trading agencies.

11. Salient Features of 2009 Monsoon

11.1 Although rainfall reached about one week in advance (23rd May, 2009) in Kerala but its advancement to North stagnated soon for about 10 days and again regained advancement northward at fast rate. However, deficit was negative right in the first week of June in the country as a whole as well as in all the four broad regions (Table 2). The rainfall deficit reached maximum in the end of June, temperature also increased above normal, damaged vegetables and reduced milk yield especially of cross-bred cows. The country's average rainfall deficit decreased from -54% to -19% progressively during July and reached normal only in Central and South peninsula. Drought again intensified after 5th August, 2009 and further forecasts are not very encouraging.

Table 2. Week by week progress of monsoon rainfall, 2009

Period ending	Country as a whole	Northwest India	Central India	South Peninsula	North East India
03.06.09	-32	-40	-50	-14	-32
10.06.09	-39	-31	-56	-15	-44
17.06.09	-45	-26	-72	-21	-46
24.06.09	-54	-49	-73	-38	-55
01.07.09	-46	-45	-59	-31	-41
08.07.09	-36	-50	-40	-18	-34
15.07.09	-27	-43	-15	-12	-40
22.07.09	-19	-38	03	-6	-43
29.07.09	-19	-33	01	-15	-39
05.08.09	-25	-40	-13	-18	-36
12.08.09	-29	-43	-19	-23	-36

The cumulative seasonal rainfall for the country as a whole during June 1 to August 9, 2009 has been 28% below the Long Period Average (LPA). Out of 36 meteorological sub-divisions the rainfall has been excess/normal in 9 cases only, deficient in 24 and scanty in 3. The sub-divisions with deficiency of 50% or more include West Uttar Pradesh (-53%) and Rayalaseema (-50%). The district-wise status is reported in Table -3.

Table 3 : State-wise distribution of number of districts with excess, normal, deficient, scanty and no rainfall (1st June – 12th August, 2009.

Sl. No.	STATE/UT	E	N	D	S	NR	ND	TOTAL
1	A & N ISLAND (UT)	0	1	1	0	0	0	2
2	ARUNACHAL PRADESH	2	2	7	1	0	1	13
3	ASSAM	1	8	10	2	0	1	22
4	MEGHALAYA	0	2	0	0	0	1	3
5	NAGALAND	0	0	2	2	0	0	4
6	MANIPUR	0	0	1	1	0	1	3
7	MIZORAM	0	0	1	0	0	1	2
8	TRIPURA	0	2	1	0	0	0	3
9	SIKKIM	0	0	1	0	0	0	1
10	WEST BENGAL	0	5	12	0	0	0	17
11	ORISSA	14	10	6	0	0	0	30
12	JHARKHAND	0	0	10	4	0	1	15
13	BIHAR	0	8	16	8	0	0	32
14	UTTAR PRADESH	0	1	25	38	0	0	64
15	UTTARAKHAND	0	2	5	5	0	0	12
16	HARYANA	0	0	5	14	0	0	19
17	CHANDIGARH (UT)	0	0	1	0	0	0	1
18	DELHI	0	0	1	0	0	0	1
19	PUNJAB	1	5	5	5	0	0	16
20	HIMACHAL PRADESH	0	3	7	2	0	0	12
21	JAMMU & KASHMIR	0	4	5	1	0	1	11
22	RAJASTHAN	0	7	22	3	0	0	32
23	MADHYA PRADESH	0	11	28	6	0	0	45
24	CHHATTISGARH	2	2	12	0	0	0	16
25	GUJARAT	4	7	14	0	0	0	25
26	DNH & DAMAN (UTs)	0	1	0	0	0	0	1
27	DIU (UT)	1	0	0	0	0	0	1
28	GOA	0	1	0	0	0	0	1
29	MAHARASHTRA	1	5	26	1	0	0	33
30	ANDHRA PRADESH	0	2	13	8	0	0	23
31	TAMILNADU	3	3	12	12	0	0	30
32	PONDICHERRY (UT)	0	0	1	0	0	0	1
33	KARNATAKA	6	12	7	2	0	0	27
34	KERALA	0	9	5	0	0	0	14
35	LAKSHADWEEP (UT)	0	1	0	0	0	0	1
		0	0	0	0	0	0	0
	TOTAL	49	128	245	104	0	7	533
Percent Distribution of 504		7%	21%	50%	22%	0%		

11.2 Water Reservoirs and power/energy position:

Water storage in reservoirs is a very good regionalized and robust indicator of realistic rainfall in the vast catchment. It is much better and practical parameter as compared to point estimate measured by rain-gauges.

Table 4: Filling up of the reservoirs in 2009 (as on 13.8.2009)

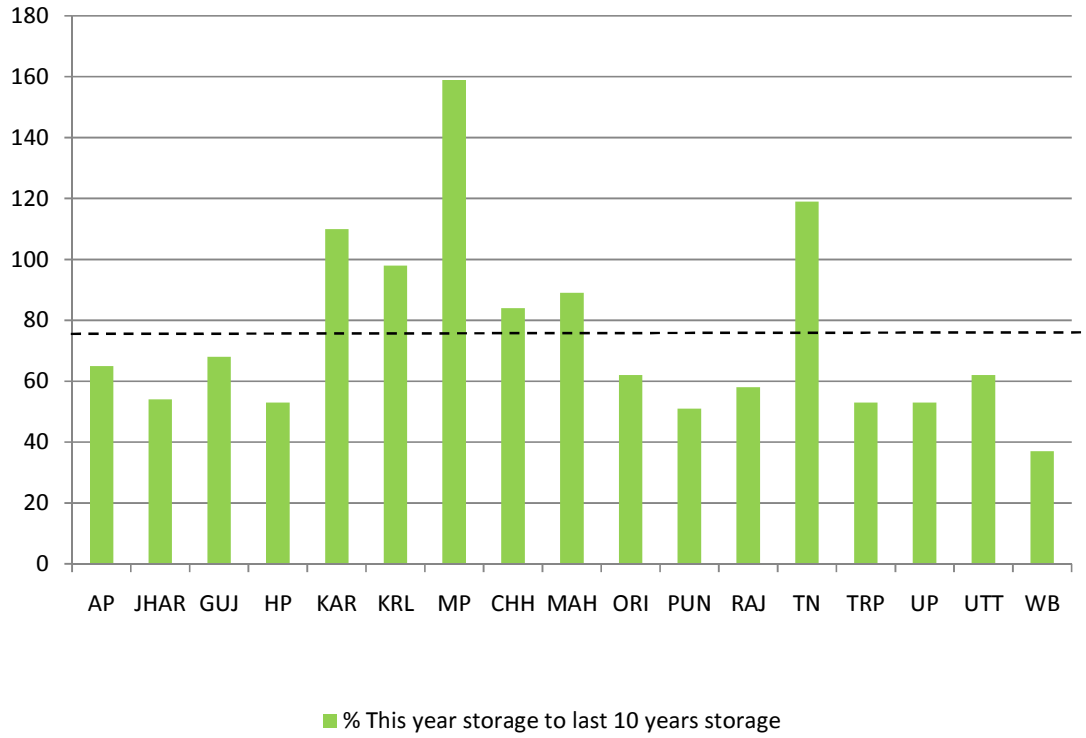
Region	%age live capacity at FRL*	%age of last 10 year average
Northern	30	55
Eastern	27	50
Central	30	36
Western	39	49
Southern	65**	59

* Full Reservoir Level ** mainly Karnataka

The filling of reservoirs in 2009 in Northern and Eastern regions was less by 18 to 20% of past 10 year average. State-wise latest position of dams is shown in Figure 1. Weekly reservoir storage position of 81 important reservoirs of India as on 13th august, 2009 reveals that 11 states (Andhra Pradesh, Jharkhand, Gujarat, Himachal Pradesh, Orissa, Punjab, Rajasthan, Tripura, UP, Uttarakhand and West Bengal) have less than 75% storage compared to corresponding period storage of last 10 years average storage. This suggests significant effect of deficient monsoon on hydrologic drought and its consequences on the remaining *Kharif* and *Rabi* irrigated areas, municipal and industrial water supplies. This indicates widespread deficiency of rainfall in the vast catchment and loss of hydro-electric power generation. Higher filling of Southern reservoir was mainly due to high rainfall in Karnataka. Significantly reduced river flows adversely affected irrigation in the run of the rivers projects and barrage based canal systems of UP, Bihar etc. Release of water and hydro electric power generation has been curtailed in the Northern and Southern dams. Abnormally high consumption of diesel, purchase of electricity in the spot market at exorbitant rates has been reported in Punjab, Haryana, UP, Bihar etc. and subsidy on diesel also announced by the government to pump ground water for supplementing water supplies. There are several other ripple effects.

STORAGE POSITION OF IMPORTANT RESERVOIRS OF INDIA

WEEK ENDING 13.08.2009



11.3 Other indicators of drought:

Delay in sowing or transplanting, shortfall in the area sown/transplanted, poor germination, mortality of germinated seedling, wilted crops, excessive consumption of energy in drawing ground water, reports of the press and media are several indirect parameters of assessing drought.

BOX - 1 Characteristics of 2009 Monsoon

- The monsoon set in early (on 23rd May instead of normal 1st June) at Kerala coast and was a good start.
- The 'Aila' Cyclone in the Bay of Bengal disturbed the normal monsoon pattern just after its setting in and discharged the system completely.
- This weakened the early monsoon advance landwards and its progress towards north was tardy.
- Lack of clouds and rainfall, and clear sky in the northern India raised air temperature during the second fortnight of June which damaged vegetables and had adverse effect on miltch animals, especially cross-bred cows.
- This year, so far no 'Westerly System' has set in the North India and deficit of rainfall continues.
- The rainfall is patchy, scanty and lacks normal vigour in the North India
- Droughts have happened in the traditionally flood prone areas of Assam, Bihar and high rainfall areas of Jharkhand, Uttar Pradesh and Himachal Pradesh.
- Drought prone areas of Rajasthan, Gujarat etc. had relatively better rainfall.
- For the first time in the history of drought management, electricity and diesel (energy) are in great demand of the States.

12. Drought Management Strategy for 2009

In most of the drought situations normal cropping systems and cultivation practices are not possible especially under rainfed conditions. In irrigated areas also, additional efforts are required for efficient utilization of resources with suitable water management strategy and agronomic manipulations in view of higher demand and reduced supplies. The implications of delayed monsoon are more devastating in dry land agriculture without ground water utilities. Under such a situation, suitable steps are needed for growing alternative crops, their varieties, special cultural practices, plant protection measures and efficient nutrient, soil and water management so as to contain reduction in production to the minimum possible. In 2009 early arrival of monsoon triggered the process of sowing and transplanting in some parts of the country. Subsequent dry spells led to mortality, poor crop stand and even re-sowing with additional expenditure in the inputs. The short term strategy to moderate current drought impact and medium or long term strategy needed to negate such calamities in future are discussed below.

Short Term Strategy of Contingency Planning

13. The probable date of monsoon withdrawal in north-west India is second week of September and system is quite weak right from the beginning. The weathermen do not predict good rains particularly in north-west India. The fall-out of erratic and subdued monsoon rainfall in various parts of the country on *kharif* and *rabi* production is imminent. The success of *Kharif*, pre-*rabi* and *rabi* planning will largely depend on how best the following issues are addressed: (i) low water level in 81 major reservoirs of the country which are life line for providing drinking water, irrigation water and generating electricity, (ii) poor economic condition of the rainfed farmers and additional investment in re-sowing or re-planting and they will not be able to invest on costly inputs for pre-*rabi* and *rabi* sowing, (iii) low or no stored water in micro-watershed structures for providing life saving, pre-sowing and/or supplementary irrigation for *rabi* sowing and (iv) probability of occurrence of rainfall in end of September or first fortnight of October. Success of good harvest of *kharif* crop and *rabi* sowing particularly in rainfed regions will depend largely upon short term measures. Productivity and production are the most crucial issues for which immediate planning is required:

(i) Judicious use of surface and groundwater for drinking and irrigation.

(ii) Ensuring availability of quality fodder to animals for the period from September, 2009 to June, 2010.

(iii) Livestock management including establishment of fodder/feed depots and cattle camps especially for non-miltching and scrub animals.

(iv) Selection of crops, cropping sequences and agronomic practices for drought affected areas.

(v) Promotion of subsidiary income and employment generating activities.

(vi) Gainful implementation of NREGA, RKVY, NFSM, NHM, RGGVY, BRGF and other schemes.

(vii) Deployment of Information Technologies for gathering and disseminating information almost on real time basis.

13.1 Irrigation

Drinking water should be the first and irrigating of crops second priority. The 2009 drought is widespread in the states having both surface and ground water irrigation resources. There are some general issues cutting across

regionally differentiated state specific interventions. Irrigation for sowing or transplanting of the crops and saving of the already sown/transplanted crops is upper most consideration of the contingency measures. Canal irrigation generally based on reservoirs like Tehri dam has many possibilities and flexibilities to adjust or adapt with the rainfall pattern and deficiency. Some of the irrigation schemes especially of UP, Bihar, etc. are based on run-off of the rivers or barrage based systems and have limited scope of adaptations to drought.

13.1.1 Rescheduling of the irrigation rosters:

Elaborate rosters are generally prepared by assuming normal rainfall and availability of discharge in the canal systems. However, during excessive rainfall deficit, rescheduling is called upon to optimise use of depleted water supplies and high demand. During field visits in the States and direct interaction with the farmers, it was observed that 40-50% of the canal-tails did not receive water even for one irrigation whereas other tails were lucky in having 2-3 irrigations. Assuring at least one irrigation in each tail will make a lot of difference for saving or sowing the crops on a very large area. This would require determined, motivated and skilled management by the managers and operators of the canal system.

Similarly, within a branch, the tail-enders did not receive any irrigation whereas those located at the beginning of the tail enjoyed 3-4 irrigations. This will also require proper enforcement of modified operation system by the Irrigation Department so that all farmers of a tail get their share equitably and this will also result in over-all higher production.

Desilting, repairing, renovation and construction of new conveyance system by utilising opportunities under NREGA, BRGF, MPLAD funds, etc. may be undertaken. In the reservoir based systems like that of Bhakra, Tehri, Nagarjuna Sagar, etc. extended release of water may be re-planned both for the existing *kharif* and subsequent *rabi* season.

13.1.2 Ground-water utilisation:

Bore wells/dug wells energised by electricity and diesel have multiplied in recent years and following points are very important for optimising services of these heavily invested utilities.

i) Efficiency of the electric pumps is higher than the diesel pumps. However, because of the subsidised or free supply of electricity, the farmers do not care for the efficiency of the motors or pump-sets and look for cheaper options in the market. Since supply of power is getting limited year by year, farmers should be advised to go in for more efficient but relatively expensive

pumping systems. After all they will be able to irrigate more areas for a given supply of electricity.

ii) **Uninterrupted supply of electricity:** Frequent tripping of the supply was complained to almost all the teams who visited various States and interacted with the farmers. Frequent tripping leads to repeated irrigation of the same spot whereas rest of the field remained uncovered. Farmers were less interested in 8 or 9 hour supply but are very particular about continuous supply without any break so that they are able to complete the entire field with the limited water supply.

iii) Proper maintenance of the motors and pumping sets to reduce friction by way of greasing and other maintenance should be advised for efficient pumping.

iv) Sharp bends and excessive height of the delivery pipes also yield less water.

v) As per the existing electricity tariffs and diesel prices operational expenditure on irrigation by diesel pumps is 4-5 times of the electric pumps. There are several possibilities to derive maximum benefits by proper maintenance and installation of diesel pump-sets. Ultimately, diesel pumps may be phased out by linking with RGGVY (rural electrification) scheme.

vi) In case of rice, continuous standing of water is required only in the initial 15-20 days so as to suppress growth of weeds. However, later on, irrigating one day after disappearance of water is the most economical and efficient way of scheduling irrigation.

vii) Sowing of cotton, soya bean, maize, etc. on the ridges and furrows and letting water in alternate furrows can save 20-30% water.

viii) Sprinklers for cereal crops like wheat and drip system for widely spaced crops sown in lines like sugarcane, cotton, maize etc. can give an efficiency of 80-90%.

ix) Harvested rainwater stored in unlined tanks and ponds should be used for pre-sowing or first irrigation to ensure uniform germination. Storing this water for later period will result into infiltration and evaporation losses.

13.2 Use of poor quality water:

Rainwater is the ultimate source of surface and ground water resources. Because of deficient and scanty monsoon rainfall in most parts of the country, recharging of ground water is not taking place. Water management issues of current concern, therefore are: (i) less exploitation of ground water for irrigation, (ii) increased concentration of salts in the soil profile and

groundwater, (iii) increased concentration of specific toxic ions like fluorides and nitrates in water and (iv) non-availability/less availability of drinking water for animals in natural storage structures such as ponds, lakes, tanks etc.

Studies on groundwater resources indicate that 25 to 84% of the poor quality waters are also being used for cropping in several states of the country such as AP, Gujarat, Haryana, Karnataka, MP, Rajasthan, UP etc. and most of them are currently under the threat of drought. Based upon climate, soil, water and crop factors, the Central Soil Salinity Research Institute, Karnal has standardized water quality guidelines which must be kept in mind while irrigating the crops using poor quality ground water in drought prone areas. In a normal rainfall year salinity developed in soil due to poor quality irrigation water gets leached or washed. However, this does not happen in a drought year and one has to deal with relatively higher salinity levels. Some specific strategies for efficient use of poor quality water are:

(i) Mixed and/or alternate use of limited good quality and underground poor quality waters for irrigation.
(ii) Cultivation of salt tolerant varieties like CSR-10, CSR-13, CSR-27 and CSR-30 of rice; KRL 1-4, KRL 1-9 of wheat, CS-52 of mustard, CSG (8962) of gram.

(iii) Farmers having residual sodium carbonate (RSC) rich waters should be encouraged to use this for irrigation judiciously after amending with gypsum or as soil amendment. In order to facilitate quick utilization, it is recommended that gypsum should be kept in baskets (made from bamboo/mulberry sticks) and covered with jute sack and placed under the source of irrigation so that improved water is used for irrigation.

(iv) The states of Haryana, Punjab, Rajasthan, Madhya Pradesh, Uttar Pradesh and Andhra Pradesh should therefore, need to take special extension programmes and supply gypsum freely and/or on soft loan term basis to promote use of alkali (poor quality) waters.

(v) In the saline areas, if there is no rainfall during August, it is proposed that farmers be advised to give pre-sowing irrigation with saline waters and go in for *toria* cultivation in September or mustard later on.

(vi) The farmers having saline waters may go for *Isabgol* cultivation as this crop can withstand poor quality saline water irrigation up to EC 8dS/m during the *rabi* season and give profitable yield. *Matricaria* is another medicinal crop which can be cultivated even up to soil pH 9.5.

(vii) Resorting to dry sowing of mustard followed by irrigation with saline water especially in light textured soils.

(viii) There should be national level programme for digging farm ponds to store good quality rain water. Such farm ponds should be sealed using plastic linings or other effective method to reduce seepage losses and conservation of water be taken up at state level. This good quality water can be used conjunctively with poor quality groundwater.

(ix) In a sizeable area of Rajasthan, groundwater is also loaded with fluorides and nitrates. Retro-fitting of hand pumps have been designed by state agencies for safe use of these waters for drinking. Immediate efforts are required to install these attachments in all drought prone areas having fluoride and nitrate problem for drinking purposes.

13.3 In-situ rain water conservation

Land shaping (if the soil depth permits), contour cultivation, field/contour bunding, tie ridging , digging of trenches, ridges and furrow system of sowing, raised on sunken beds are important practices for conserving and managing rain water for realising higher productivity.

13.4 Tanks and farm ponds:

About 11-37 % run-off is generated even by the delayed monsoon and should be stored in the farm ponds or tanks. These will recharge ground water during normal or excessive rainfall year. Rainwater stored in self sealing or lined ponds can be used for irrigation if there is long break in the rainfall or for pre-sowing of the *rabi* crops to ensure proper germination.

13.5 Contingent cropping:

Selection of crops, cropping sequences and agronomic practices are very important. Relatively more drought tolerant, deep rooted and short duration crops, varieties and cultivars are available for different agro-ecological and rainfall situations. If the rain is excessively delayed or main crop has failed cultivation or re-sowing with fodder is the best option. Fodders can be harvested at any stage keeping in view sowing of the next *rabi* season crop. Following Annexures discuss the details of contingency crop planning.

i) Date bound contingency crop plan for rainfed areas located in different meteorological sub-divisions is presented in Annexure 1.

ii) A list of suitable early maturing varieties of different *kharif* crops is appended as Annexure 2.

iii) Crop-group/crop-wise contingency plan for *kharif* is discussed in Annexure 3.

iv) Contingency plan relevant to all crops and cropping systems is covered in Annexure 4.

v) Specific contingent plan for Boro or Summer Cropping is given in Para 17.1.

13.6 Application of fertilizers:

Rainfed soils are both hungry and thirsty but due to inherent risk of the un-irrigated rainfed crops, the farmers are always reluctant to invest in basal dose of fertilizers. Top dressing with fertilizer is done generally after establishing good crop stand. Some of the cotton growers are trying application of the fertiliser-solution around germinated seedling with the help of sprayers by removing nozzles. Application of fertilizers and even micro nutrients is very essential to optimise production of rain or irrigation water. Intercropping or mixed cropping with legumes or sowing pulses in cropping sequence also improve soil fertility. Farm yard manure and vermi composting is specifically important since they enhance water retention of the soil. Phosphorus, sulphur and nutrient solubilising bacteria, fungi, michorhiza and poly-culture are other ways of fertilizing soil. Risk factor can always be taken care of in the insurance of the crops. Soil Health Cards can also be used for optimised application of fertilisers.

14. Arrangements of Quality Fodder

Livestock is most resilient livelihood for adapting to drought and other calamities all over the world. Animals can be out migrated, fed on stored fodder or can be liquidated under most adverse conditions. To feed nearly 185 million cattle heads and 97 million buffaloes along with large number of sheep and goats in the prevailing drought condition seems extremely challenging. A large number of unproductive male and female cattle are bound to suffer badly as farmers will prioritize saving their productive animals and all available resources will be deployed for their feeding.

During drought, availability of green fodder and natural grasses is drastically reduced leading to infertility of animals which can be restored in 2-3 years only. Even the supply of crop residue, normally used as maintenance ration, is reduced whereas demand is increased due to lesser supply of greens. To mitigate/moderate the situation and to save the animals, following strategy may be adopted in coming months:

(i) Reduced sown area under paddy, maize, sorghum (jowar), pearl millet and their curtailed productivity or poor growth of grasses will lead to shortages of fodder and feed.

(ii) As the sowing of main rabi fodder crops will start in October-November, catch crop of maize, *bajra*, sorghum, cowpea, *bajra* + cowpea, maize + cowpea and *toria* may be taken up after light showers during August-September.

(iii) Rapeseed and mustard, Chinese cabbage, *gobhi sarson* and maize may be sown in September for fodder purpose wherever feasible. These crops will be harvested by November to facilitate the sowing of *rabi* cereals.

(iv) Under irrigated conditions, sowing of *berseem* with Chinese cabbage in last week of September may be taken up for early availability of fodder. *Senji* and *lucern* may be preferred over *berseem* cultivation.

(v) Dual purpose crops like barley (varieties RD 2715, RD 2035, RD 2522 and BH 75) may be sown in October. One cutting may be taken for fodder at 50-60 days after sowing and subsequent regenerated crop left for grain production.

(vi) Oats may be grown in October as multicut fodder to ensure availability of green fodder for longer period.

(vii) For quick growth in cereal fodders and higher crude protein contents, application of urea as foliar spray may be taken up.

(viii) Looking to scarcity of crop residues, burning of paddy straw and stubbles should not be allowed in Punjab, Haryana and UP. A preliminary estimate indicates that about 20 million tonnes of rice straw is burnt in these three states alone which creates problem of environmental pollution. This can be properly harvested, baled, densified and fortified using 4% urea or molasses and transported to areas of fodder scarcity. Standardised machinery for harvesting, baling, densification and fortification is available with Punjab Agro Federation and in the market. Some budget should be earmarked out of the calamity Relief Fund or National Calamity Contingency Fund for implementation of this plan on priority. Perennial grasses like Bhabhar grass (*Eulaliopsis binata*), guinea grass (*Panicum maximum*), hybrid napier, *Dichianthium annulatum*, *Chloris gayana* etc. which grow naturally during rainy season in different parts of the country can also be properly harvested, baled and fortified for animal feeding either at site or transported to scarcity areas. During this year, wheat straw should also not be burnt in Punjab, Haryana and U.P. It should be properly harvested, baled and densified by machinery used for paddy straw. Stovers of

maize and mustard wherever available should also be transported to fodder scarcity areas. Soybean chaff can be mixed with other fodders up to the extent of 30 percent.

(ix) Sugarcane tops and dry sugarcane leaves from sugarcane growing areas may be transported, enriched for crude protein content and fed in scarcity areas. In areas where sugarcane crop is drying due to moisture stress, whole crop can be harvested and used as fodder.

(x) If deficit is very serious, sugarcane baggase and press mud may be treated and transported to deficit areas for survival feeding.

(xi) Partially damaged wheat grain may be diverted for feeding to save the productive animals. However, substandard wheat having very high aflotoxin content should be avoided as the same may result in abortion in pregnant animals.

(xii) Efforts should be made to increase the production of supplements like UMMB (Urea Molasses Mineral Block) lick, which can be easily transported (as animal chocolate) to be offered to the animals along with crop residues to increase their palatability and digestibility. For utilizing residues of crops which are normally not fed to livestock, the practice of Total Mixed Ration (TMR) should be propagated. Residues of such crops can be incorporated in TMR at 10-15% level.

(xiii) Possibility of feeding of tree leaves after lopping and grazing of grasses in forest areas may be explored in consultation with Forest Department. Pods of trees like *Prosopis juliflora* can be collected and supplemented as feed source. These pods contain nearly 13% protein and 25-30% sucrose. In Gujarat, these pods are already used upto 30% of the total ration of the animals. Its' leaves can also be used as fodder upto 10% of the ration. Similarly, leaves and fruits of other trees such as *Leucaena leucocephala, Ailanthus excels, Prosopis cineraria, Salvadora persica, Acacia spp., Albizia spp.* etc. may be collected to supplement protein content in roughages and moderating fodder scarcity.

(xiv) Vegetable/fruit wastes may be collected from the market yards and factories processing such foods (like SAFAL). These are generally high moisture content feeds. In the moist form, these could be distributed to farmers around the factories. After sun-drying these could be transported to deficit areas. The nutritive value of these by-products is reported quite high. Apart from providing additional feed resource, such type of recycling also helps in reducing the environmental pollution.

(xv) Export of feed ingredients such as oil meals or de-oiled cakes etc. may be suspended temporarily and diverted for surviving the productive animals in drought affected areas.

(xvi) Animal camps may be organized along nearby canals like Indira Gandhi *Nahar* of Rajasthan having adequate drinking water. Fortunately there are large number of canals in most of the states afflicted by drought-2009. Farmers along the canals may be persuaded to cultivate fodder crops only and may even be compensated suitably.

15. Livestock Strategy

i) Seasonal migrations of animals from lower to higher hills or from one region to other is an age old practice or safety net. However, there is a need for halting large scale migration of livestock from drought prone states to other states due to emerging interstate concerns or disputes especially on quarantine considerations. Migration of the animals to higher Himalayas or other hills, and from Rajasthan to Madhya Pradesh and Uttar Pradesh is an age-old drought escaping strategy. Fodder grasses are also generally transported from surplus to deficit states and restrictions should not be imposed. Irrigated states like Haryana, Punjab and Western Uttar Pradesh may also not be able to spare fodder for arid regions because of the sub-normal fodder production in their own territory. The best option is to open fodder depots for milching animals which farmers will never deposit into the cattle camps and establish cattle camps for dry and scrub animals. These camps should be established along assured source of water or canals for drinking and growing irrigated fodder. Facilities like storing densified roughages transported from other parts of the country should also be established adjacent to these camps. Immediate efforts are needed to grow fodder crops like oats, barley, *kasni* and *lucern* etc. in the canal command areas. Farmers might have to be compensated for abandoning food or commercial cash crop to meet contingent fodder requirements.

ii) Resorting to alternate day watering to camel, sheep and goats. Experimental evidences show that even watering twice a week did not have much adverse effect on body weight of the sheep.

iii) Avoiding long distance grazing as tired animals need more and frequent watering and feeding.

iv) Since stall feeding adversely impacts the breeding efficiency in case of sheep, therefore, sheep should always be resorted to natural grazing.

v) Periodic health check-up of all animals retained by the farmers and in the cattle camps and ensuring recommended vaccination schedule for all major

diseases of the livestock is necessary. De-worming will improve fodder and feed absorption.

vi) Special care is required for productive, lactating and pregnant animals. These animals must be supplemented with additional concentrates and fodders. Most of such animals will be retained by the farmers and arrangements for fodder, feed and drinking water should be made accordingly.

16. Promotion of Subsidiary Income and Employment Generating Activities

Some of the activities which can be initiated immediately are:

(i) Extraction of gum from arid land trees and bushes such as *Acacia Senegal*.

(ii) Collection of *Prosopis juliflora pods* and its post harvest processing as animal feed and human food.

(iii) Mushroom cultivation, bee keeping, sericulture, tasar cultivation etc.

(iv) Salt making from saline ground water.

(v) Commercial raising of the nursery for trees, vegetables and annual flowers.

(vi) Multiplication of root stocks as well as nursery of fruits and flowers.

17. Compensatory Production for Kharif Deficit

In order to compensate for the loss of production during *kharif* 2009, advance and meticulous planning for *rabi* and summer crops has become crucial to cover up *kharif* deficit. Improved technology for *rabi* including Resource Conservation Technology for enhancing production and profitability of wheat and other rabi crops, promotion of winter maize and improved technology for *rabi*/ summer rice, particularly for Boro-rice areas will need more focussed attention. Preparations for pre-*rabi/ rabi* and summer crops will require region specific cropping plans including identification of suitable crops and varieties, supply of seeds and inputs and promotion of improved agronomic, soil and water management practices.

Extra efforts for intensification of agricultural activities in normal and surplus monsoon areas/ States during ongoing *kharif* and ensuing *rabi* season for enhancing productivity assumes greater importance to capitalise on good

resource base to compensate for the *kharif* production shortfall in deficit monsoon hit areas of the country.

17.1 Boro Rice

Non-*kharif*, Boro and summer rice has been cultivated traditionally in water logged, low-lying or medium lands with irrigation during November to May in Eastern India. It is a relatively long duration (six month) crop as compared to *kharif* season (4-5 months). It, therefore requires more number of irrigations and also being non rainy season period. Fortunately boro rice cultivated areas have reliable ground water resources. Nursery is raised in November and transplanted in January. Boro is a winter season, photo-in sensitive, transplanted rice cultivated on supplemental irrigation. Rapid expansion of boro rice has taken place in recent years in West Bengal and Bihar and is fast expanding to more areas in Bihar, West Bengal, Assam, parts of Eastern U.P., Orissa and Andhra Pradesh. Boro rice in India expanded from 1.35 million ha (1991) to 2.95 million ha (2000), and is spreading further. Boro rice has 2-3 times higher productivity (5-6 t/ha) in deep water areas of eastern India against productivity of traditional kharif rice (1.3-2.5 t/ha). Its yield is more on account of better water management, longer duration (165-180 days), more sunshine and least infestation of pests and diseases during boro season.

BOX – 3 Major Boro Rice Growing Areas

States	Districts
Bihar	Purnia, Katihar, Madhepura, Madhubani, Darbhanga, Supaul, Kishan Ganj, Saharsa (Low-lying chaurs and chauri)
Eastern U.P.	Ballia,Basti, Gorakhpur, Deoria, Gazippur (Lake, river, nalaha, etc,)
West Bengal	Bardwan, 24-Pargana, Nadia, Midnapur, Bankura
Orrisa	Balasore, Bhadrak, Kendrapara (Low-lying areas of coastal belt)
Assam	Nawgaon, Karimganj (Lake areas)
Tripura	
Meghalaya	

Boro/summer rice takes advantage of residual moisture after the harvest of kharif rice especially in low lying regions, areas adjoining canal and roads, chaur lands etc. Opportunity for intensification of boro rice cultivation in such areas of Eastern India should be capitalised for enhanced rice production to meet expected shortfall of 2009 *kharif* rice production. Suitable varieties of Boro/ summer rice for different Eastern States are given in Annexure - 5. In view of limited water availability, the recommended nursery management, land preparation, agronomic and water management practices are given in Annexure - 6.

Intensification of boro/summer rice with improved technology and inputs (water and fertilizer management) in Eastern India will help in obtaining additional rice production. This may also have to be incentivized by supporting low cost polyhouse and/or low plastic tunnels for raising nursery to avoid cold injury to seedlings where temperatures are low. Sprinkler irrigation of main crop may be promoted to effect water saving especially where groundwater is used.

Besides boro/summer rice in Eastern India, intensive cultivation of rice with better management and inputs should be emphasised during NE monsoon period in States like Tamil Nadu to cover up deficit production of *kharif* rice in north India. Storage position of important reservoirs in Tamil Nadu and Karnataka is also favourable as on today. Appropriate provisions for supply of energy (electrical/diesel) will need to be put in place for lifting water, wherever needed.

17.2 Winter Maize

Karnataka, Andhra Pradesh and Bihar are the three largest maize producing states with 2.72, 2.46 and 1.72 million tons respectively closely followed by Uttar Pradesh and Maharashtra. Cultivation of maize in winter season started in mid 60s in some pockets of Bihar and South India. Yield obtained during this season is invariably higher (>6 t/ha) than the Kharif season yield (2-2.5 t/ha.) due to long duration of growth and least infestation of pests and diseases. In Bihar, maize can be taken up in all the three seasons. In recent years, significant changes have occurred in maize production and utilization due to increasing commercial orientation of this crop and rising demand for diversified end users, especially for feed and industrial uses. A sizable number of districts (110 districts), in the states of Andhra Pradesh, Karnataka, Bihar, Maharashtra, Uttar Pradesh, Madhya Pradesh, West Bengal, Orissa, Gujarat, Chhattisgarh and Tamil Nadu have potential for growing winter maize (Annexure-7). In Bihar alone, there are 18 such districts out of 38 districts.

There is a vast opportunity for intensification of winter maize during flood free period in these and other districts to compensate for the loss during Kharif season with proper planning for seeds, inputs and improved management practices and crop diversification. The medium and uplands where subsistence yield of wheat, rabi rice and other winter crops is obtained, could be substituted by winter maize in Bihar, West Bengal, Eastern UP, Orissa, parts of Jharkhand etc. Maize varieties like Shaktimaan-1,2,3,4, Laxmi, Dewaki, Rajender-1,2, High Starch and Ganga-11 are the recommended varieties for rabi maize in Bihar region. In general, any late maturing single cross-bred variety of Kharif season is equally good for winter season. Winter maize (170-180 days duration) has the clear cut comparative advantages of low incidence of diseases and insect pests, is not affected by temperature rise during winter (as the wheat is) and do not suffer on account of heavy rainfall. Cultivation of maize with zero-tillage drill is also gaining momentum as it can make best use of residual moisture, reduce cost of cultivation and thereby increase profitability.

17.3 Wheat and other Rabi Crops

Timely sowing of wheat and expansion of zero tillage technique to cover more and more areas in the Indo-Gangetic plains of UP and Bihar for enhanced productivity, water and cost saving. In UP and Bihar, zero tillage machines should be promoted at massive scale through providing liberal subsidy for adopting zero tillage. This will advance the sowing of wheat in otherwise traditionally late sown conditions and help achieve higher productivity. The sowing of wheat in States like Haryana and Punjab should preferably be done during 25th October to 25th November under timely sown condition. The old varieties like PBW 343 and PBW 502, which have become susceptible to rust diseases, should be replaced in these States with resistant varieties like DBW 17 and PBW 550 possessing high potential. The situations where harvest of paddy is delayed, the early maturing wheat varieties like PBW 373, WH 1021, PBW 509, DBW 16, UP 2425, Raj 3765, PBW 590 etc. should be sown preferably using zero tillage drill.

17.4 Intensification of Rabi pulses and oil seeds

Concerted efforts may be made in enhancing productivity of pulses in Tal areas of Bihar through better water and fertilizer management. Rice fallow areas in eastern and central India may be targeted for pulses like chickpea, lentil etc. together with moisture conservation measures. In acid soils of eastern region, cultivation of pulses should be promoted with application of lime plus recommended dose of fertilizer for enhancing production and productivity of pulses.

Medium and Long Term Strategy

Medium and long term strategies should aim at creating resilience or robustness by various mitigative measures productively.

18. Securing Good Quality Water in Drought Prone Areas

i) Networking of rivers, reservoirs, lakes and other water bodies existing in high rainfall areas which are prone to periodic flooding. Transferred water could be used for ground water recharging and to fill up dried lakes, water storage structures in dry areas whenever such necessity arises. This seems a viable option because the country receives more than one metre average rainfall in a year with lot of inter-regional variation.

ii) Surface stored water may last only for a few years whereas more than 10,000 year old below ground waters have been analysed in Jaisalmer (Rajasthan) by radio tracer technique. Ground water recharge in dry areas with introduced water, *in-situ* and *ex-situ* rainwater harvesting will be sustainable provided its quality is retained. Field, farm or contour bunding, treatment of micro-watersheds, contour cultivation, vegetative barriers, gully plugs etc. can go a long way for conserving rainwater.

iii) Less exploitation of ground water by resorting to low water demanding crops, introduction of precision micro-irrigation techniques such as drip and sprinkler methods in overexploited/critical areas and matching water application schedules with critical growth stage concept may be prioritized.

iv) Collection, conservation and proper storage of rainwater for domestic use and for providing life saving irrigation is quite effective. Promotion of roof water harvesting, construction of *nadis* and *khadins* may be promoted. Periodic desilting and renovation of village ponds, tanks and other storage structures through NREGA, BRGF, MPLAD, IWMP funding provide ample opportunities. Strict implementation of watershed based agricultural development sequenced from ridge to valley in drought prone areas, holds a great promise.

v) Formulation of strict guidelines for judicious use of water for domestic and industrial purpose in all drought prone areas. These guidelines must be backed by proper legal provisions. There is also an urgent need to declare water as a national asset.

vi) Conjunctive use of ground water by installing bore wells in canal command area will increase overall efficiency and sustainability.

vii) Recycling of used/waste waters after proper treatment and reclamation for agriculture, human and animal consumption. The domestic sewage water which is not mixed with industrial heavy metals can be directly used for raising agro-forestry, industrial bio-mass and parks. Waters having high fluoride and nitrate contents particularly in Rajasthan can be purified by using filter assemblies developed by state government agencies. Highly polluted industrial effluents can be used for irrigating forest plantations after working out their chemical composition and tolerance limits of tree species. This will be a safe disposal option because heavy metals will not enter the animal-human chain.

viii) Joint management of forest and arable land in forest fringe area to harness rainfall and minor forest products requires inter-departmental cooperation and coordination.

ix) Diversification into less water demanding cropping systems. Vast range of options are available to make preferred choices.

19. Perennial and Non-conventional Fodder:

i) Deep rooted bushes, trees, grasses and modified plants of cactus are highly drought tolerant and will be a durable adaptation to climate changes. Perennial component of vegetation may be enhanced in arid and semi-arid regions. Improve natural pasture/grazing lands by *in-situ* rainwater conservation, reseeding, inclusion of leguminous component such as stylo, sirato etc. and introduction of top feed fodder trees and bushes such as *Prosopis cineraria, Hardwickia binata, Albizia* species, *Zizyphus numularia, Colospermum mopane, Azadirachta indica, Ailanthus excels, Acacia nilotica* etc. Experimental evidences indicate that carrying capacity of arid lands can be raised from 0.5 sheep/ha to 7.3 sheep/ha by proper management of pasture lands. The less productive grasses can be replaced by recently developed more productive and drought tolerant varieties of *Cenchrus ciliaris*, *Cenchrus setigerus* and *Lasirius sindicus.*

ii) Introduction of fodder trees, bushes and grasses as rehabilitation option on all kinds of wasted and abandoned lands. Rehabilitation success stories need to be scaled up on large plots in drought prone areas.

iii) Introduction of fodder spineless cactus as alternate source of green fodder especially in arid regions of Rajasthan and Gujarat requires international partnerships. They can be cultivated in very low rainfall areas and are highly drought resistant evolutions.

iv) Up-gradation of productivity potential and quality of non-conventional perennial vegetation of fodder value existing naturally in drought prone areas through selection, breeding, standard management and agronomic practices. Identification and documentation of anti-quality factors in such plants and developing strategies to detoxify such harmful compounds. Technology needs to be generated to remove/reduce alkaloids from leaves of *Prosopis juliflora* which is available in plenty in drought prone areas.

v) Development of fodder varieties of cultivated crops having tolerance for varying degrees of drought. Emphasis should be on dual purpose varieties of pearl millet, sorghum, barley and oats. Improvement work on drought tolerant grasses, bushes and trees should also be undertaken. There is always a shortage of seeds of grasses and bushes. Rigorous efforts will be required to ensure the availability of quality seed of fodder crops in general and grasses and legumes in particular.

vi) Creation of permanent fodder, feed and seed banks in all drought prone areas (a) using residues of crops like rice, wheat, mustard, maize, groundnut, soybean, chick peas, lentil, etc. grown in irrigated areas of Punjab, Haryana and Western U.P., (b) harvesting and collection of perennial vegetation particularly grasses which grow during monsoon in drought prone areas and other areas of the country, (c) leafy meal of fodder trees and (d) potentials of forest land have not been utilized. Each year these fodder bank resources need to be properly baled, densified and fortified at the sites of their production and then transported to the fodder banks established in drought prone areas. Standard technology of baling, densification and fortification using urea and molasses is already available. This needs to be given a practical shape. In case of non-drought years,

this material can be used for making compost, raising of mushrooms and/or rearing of earthworms for producing quality organic manure or composts.

vii) Raising drought tolerant perennial grasses, trees and bushes on field boundaries as permanent source of fodder in all drought prone areas. The selected species should have the ability to withstand severe drought, revive quickly and capacity to yield reasonable biomass of fodder value. The priority should be for exploitation of genus *Prosopis* and *Opunita*. Planting of trees and bushes on the boundaries of agricultural fields in drought prone areas will be highly useful as (i) bio-fence protection against wild animals, (ii) as an alternate source of food, fodder, fuel and income generating products during severe drought, (iii) as vegetative barriers to conserve soil and water, (iv) moderating effects of drought through moderating micro climate and (v) in some cases serve as shelter belts/wind breaks.

20. Improved Live-stocking, Breeding and Management

i) Livestock shall continue to be the backbone of livelihood due to ever increasing population and shrinking per capita resources availability. Livestock rearing generates 4-5 times more employment as compared to raising of crops which is essential due to demographic growth. Decrease population of unproductive animals in drought prone areas through castration/controlled breeding. However, while implementing it, the socio-cultural conditions of different areas of the country should be considered. Cattle/livestock insurance schemes need to be made more effective.

ii) Upgradation of indigenous livestock strictly following area specific animal breeding concept. In livestock improvement, introduction of exotic blood particularly in Rajasthan must be discouraged. There is a need for state level breeding policy for the livestock. Tharparkar cow which can graze under high temperature and produce higher milk during hot summers, needs scaling up.

iii) Creation of drinking water bodies through introduced water in grazing areas. It has been reported that more deaths of livestock occur due to dehydration than because of non-availability of fodder. The animals are forced to drink saline water. There is also a need to identify livestock species/breeds

having moderate body weight and resistance for prolonged dehydration Livestock based water management strategy which focuses on recycling of water, de-contamination and washing and flushing etc. needs to be developed.

iv) Establishment of permanent sites for cattle camps and fodder depots in drought prone areas. This is important because large scale migration of livestock from, drought affected areas to non-drought areas puts pressure on economy of those areas and subsequent problems. As far as possible these cattle camps should be established in irrigated areas of the state where assured supply of drinking water plus irrigation water to raise fodder crops is available. There should be safe provision for disposal of dead animals.

v) Because of shortage of fodder and feed, the animals are forced to graze on non–palatable and poisonous miscellaneous vegetation. There is, therefore, an urgent need of inventory of anti-quality factors in all kinds of plants growing naturally in drought prone areas. Collection, conservation and upgradation of quality of such resources must form an integral part of future research.

vi) Proper redressal of drought related animal health problems including precautionary vaccination. Emergency measures or life saving approaches such as drenching/watering, guard against heat stress, semi-liquid diet and therapeutic care, drug therapy and restoration and normalization measures need to be undertaken. These measures, however, will differ in different areas depending upon longevity of dry spell.

21. Upgradation and Fine Tuning of Crops, Cropping and Farming Systems

The strategy should include: (i) relooking and upgradation of our knowledge about mixed cropping, intercropping, catch cropping, mixed farming and multi-strata cropping concepts; (ii) promotion of agro-forestry, silvipasture, horti-pasture and sivi-horti-pasture systems etc. through large pilot scale demonstrations in farmer's participatory mode; (iii) agronomic manipulations such as zero tillage, bed furrow irrigation, fertilization, adjusting spacing, soil and water conservation through mulching, use of anti-transpirants/Jal shakti etc. and (iv) development of extra early maturing short duration area specific crop varieties including fodder crops, perennial grasses; bushes and trees. Synergies

of forest and arable land especially in the fringe area in terms of transfer nutrients, water, organic carbon etc.

22. Exploiting under-exploited and under-utilized plant resources

Large number of trees, bushes, shrubs and grasses are naturally growing as wild plants in one or the other rainfed region of the world. Such plants are adapted to rainfed situation and have tremendous potential to be exploited as a food, forage, fuel and/or as industrial crop. Some of these plants have already been exploited in different parts of the world. For example, edible cactus (*Opunita ficus indica*) is in countries like Mexico, Argentina, France, Brazil, Italy, South Africa and even in south western USA. The other uses of cacti in arid and semi-arid areas include thorn less fodder species: as live fences, vegetative barrier for soil and water conservation on sloping lands and as a wind break or micro shelers in sand dune stabilization. A summary of *Opunita* use as reported in FAO manual on Cactus is presented in Box 2. Similarly, trees of the genus *Prosopis* are growing naturally in dry areas. This plant has a wider adaptability and can be grown in almost all kinds of degraded lands. It has also been exploited economically as timber, fuel-wood and forage and feed tree in countries like Brazil, Argentina, Peru, Mexico, Senegal, etc. Its pods and leaves contain 13.6 and 12.9% protein respectively which is almost equivalent to that found in alfalfa which is considered as one of the best cultivated fodders. *Prosopis* leaves are also a good source of beta carotene and phosphorous. Other similar plants which can be exploited are: Henna (*Lawsonia inermis*), Jaffre (*Bixa orellona*), Neem (*Azadirachta indica*), perennial peanut, lablab bean (*Lablab purpureus*), snapmelon, *Kachri*, ashgourd, tropical Kudzu (*Pueraria phaseoloides*), perennial soybean (*Neonotonia wightii), Desmodium* spp., *Indigofera* spp., *dil, lasura, Salvadora, Tephrosia* etc.

Box 2. A summary of Uses of Opuntias

Food	Fruits and fruit peel, juice, pulp, alcoholic, jam, syrup
Forage	Stems/cladodes, fruits, seeds, cultivated as forage shrub
Energy	Biogas, ethanol, firewood
Medicine	Diarrhoea (stems), diuretic (flowers, root), amoebic dysentery (flowers), diabetes (stems), hyperlypidemy (stems), obesity (fibres), anti-inflammatory (stems)
Cosmetic	Shampoo, cream, soaps, body lotions
Agronomic	Hedges and fences, mulching, soil improver, wind break, organic manaure
Other	Adhesives and glues, pectin, fibres for handicrafts, paper (stems), dyes (fruits, rearing of Dactyloptus on cladodes), anti-transpirant, ornamental.

To exploit the use of under-utilized plant resources as drought mitigation approach we need to focus on: (i) Generating an inventory of under-utilized/un-exploited plants and maintain their germplasm for productivity and quality improvement, (ii) identification of limits and optimal management practices for promising species and their evaluation as monoculture/mixed communities or even as under storey crop with trees, (iii) initiation of network projects on such species particularly on *Prosopis juliflora* and edible cactus, (iv) linking research and developmental issues of under-utilized plants with already existing international networks on such plants and (v) standardization of post harvest processing techniques for value addition and marketing opportunities. Similarly, large number of plants having medicinal properties exist in the desert areas. These can be exploited economically to supplement the income of farmers in the drought prone areas. Some of the species which have been identified as promising along with their probable use are listed in Table – 5. These species are also used in allopathy, *unani, ayurvedic,* and traditional herbal systems. By propagating such wild species in the existing cropping systems and as an associative crop with multipurpose tree species is an option of great promise.

Table 5. Special attribute medicinal species of drought ecologies

Name of Plant	Uses
Commiphora wightii	Lowers the cholesterol level, Carmative, as fixative in perfumery
Cassia angustifolia	Laxative, vermifute, Cathartic, Purgative
Withania somnifera	Rheumatism, Tuberculosis, Aphrodisiac
Aloe barbadensis	Rheumatism, Purgative, liver disorder
Pedalium murex	Diuretic, impotency, Gonorrhoea and Dysuria, Demulcent, Ulcer
Boerhavia diffusa	Diuretic, Jaundice
Cyperus rotundus	Anti-peptic
Tinospora cordifolia	Fever, Tonic
Tribulus terrestris	Diuretic, Tonic
Peganum harmala	Jaundice, Asthma, Rheumatism, Gallstones, Colic pains
Calotropis procera	Cold and cough, Asthma, Fever
Capparis deciduas	Dental problems, Asthma, Boils and Swellings
Andrographis paniculata	Hepato protective.

23. Creation of Alternate Income and Employment Generating Opportunities in Drought Prone Areas.

Supplementing by non-farm income and employment reduces vulnerability by reducing poverty and dependence on agricultural resources sensitive to weather abnormalities. Landless, assetless, small and marginal farmers are also job seekers in the NREGA. This can be realized in many ways:

i) Promoting subsidiary occupations such as dairying, mushroom cultivation, sericulture, tasar, bee keeping, and value addition of products obtained from dry land crops such as trees, bushes, grasses etc.

ii) Imparting skills and tools for diversified demands for masonry, carpentry, wiring of motors, repairing of engines, tractor and farm machinery.

iii) Promoting cultivation of drought tolerant medicinal and other high value industrial crops and ensuring attractive prices by linking with markets.

iv) Promoting the use of unexploited/under exploited food and feed resources such as edible and forage cactus and genus *Prosopis.* Some of these crops are already exploited for multiple use in different parts of the world.

v) Small and marginal farmers may be employed under NREGA for creating rain water conservation and storage structures to enhance productivity of their limited land.

24. Major Policy Issues

Feed back from efforts made in the past for combating drought clearly indicates that those measures were mainly concentrated on providing immediate or short term relief during the drought period. The investments did not contribute significantly in mitigating/moderating drought impact in the current, subsequent years and forever. This calls for paradigm shift in our approach of tackling drought in robust manners. Our hypothesis for drought management should now be that drought may occur regularly in drought prone areas. With this hypothesis in mind some policy decisions will be required to save human and livestock settled in drought prone areas from the frequent vagaries of weather. Following policy measures are suggested.

24.1 Implementation of land related policies

i) Efficient crop zone concept.

ii) Agro-forestry with cloned trees in Khammam district of A.P. doubled productivity and income of tribal farmers. Conservation, up gradation and economic exploitation of perennial vegetation naturally occurring in drought prone areas.

iii) Grazing lands should not be diverted for growing agricultural crops. Grazing policy for tropical, temperate and alpine areas may be enforced.

iv) Enhance perennial component of vegetation in arid and semi-arid farm lands.

v) Promoting organic farming, vermi-composting and composite inoculums.

vi) Share cropper, actual land tillers should be eligible for loans, compensation, loan waivers, subsidies and contracting for direct sale to retailers.

vii) While acquiring land compensation to share croppers, actual tillers and workers engaged in the land use may be considered.

24.2 Water related policies

Declaration of water as National Asset and legal provision for preventing its over and un-scientific exploitation for domestic, agriculture and industrial use. Networking of rivers, reservoirs, basins etc., water management to achieve maximum use of 4400 million m^3 of water received through rainfall each year. Setting up of the basin authorities. Ground water regulation for sustaining productivity may be prioritized.

Other Policies

24.3 Implementation of fodder, feed and seed bank concept for creation of permanent feed and fodder resources in the drought prone areas.

24.4 Establishment of seed bank facility in drought prone areas. Seeds of all annual and perennial crops, shrubs, trees and other industrial crops as per contingency plan of each state/region should be available in sufficient quantity in these banks. These seed banks may be updated periodically since they may be used occasionally and private industry may not be interested in such a risky business.

24.5 State level policy for livestock distribution, management and improvement. Livestock based land use policy/watershed based livestock systems.

24.6 Policy framework for effective and workable collaboration amongst Research, Development, NGO's, Industry, Farmer, International Organization, State and Central Governments.

24.7 Damages to crops by wild life like Neel Gai (Blue bull), wild boars have become unbearable to the farmers. Such species should be removed from the list of protected animals.

24.8 Artificial price rise due to hoarding by black marketers should be controlled by proper administrative measures.

24.9 Coarse cereals may be included in PDS and procurement programme. Ultra modern Silos to prevent damages to grains during storage. Leakages in the public distribution system may be plugged very soon with the introduction of biometric Unique Identification Number being given to all citizens.

24.10 There should be a plan to compensate production losses in drought affected area by enhancing productivity elsewhere having received normal or excessive rainfall by intensive cultivation.

24.11 There should be a unique 4-5 years rolling system of credit and repayment.

24.12 Loans taken for crop cultivation many times are diverted for consumption purpose. It is better to built in consumption requirement into a comprehensive rolling loan system.

24.13 Loan service of public sector is far below that of private money lenders at exorbitant rates. Micro-credit, women and self help groups could be a way out. These institutions should be promoted and their lending limits for borrowing from NABARD and other banks should be revised upwards depending upon performance since rainfed and drought prone regions are risky, complex, diverse and under invested. Innovative safety nets of weather based insurance, means of subsidiary income, seasonal out-migration for earning wages etc., may be devised.

24.14 Value addition and marketing of niche or special attribute crops.

24.15 Power distribution grids may be strengthened to supply hiked up demand for ground water pumping in drought affected areas.

24.16 Input of diesel for pumping ground water also increases especially in Bihar, UP, Haryana, Punjab etc. and its supplies should be augmented.

24.17 Mechanization is highly essential due to completion of farming operations within limited period. Renting or custom hiring services may be created.

24.18 Value added agro-met services are called upon.

24.19 Artificial seeding of clouds for inducing rainfall may be perfected.

The time has come when the country must have a National Drought Policy. The above issues must be addressed through this national document on drought.

25. Convergence of Resources and Harnessing Synergies

Requirement of resources during natural calamities is tremendous. There are several innovative, pro-active, flexible, institutionally enabled and decentralized schemes to respond quickly for managing drought. Already sanctioned and released funds of such schemes are very attractive preposition for responding to drought quickly. Some of them are mentioned below for ensuring quick results.

i) RKVY: It is a Rs.25,000 crore scheme with approval of projects decentralized to the states. Subsidy for the purchase of seeds of crops, varieties, inputs, pumping sets etc. can be planned. Various relaxations have already been notified by the Ministry of Agriculture.

ii) NREGA: The current year budget of Rs.39,000 crore provides vast opportunities for relatively likely high demand of employment due to drought. These resources can be used for de-silting of tanks, ponds, other water bodies, canals, repairing or construction of water conveyance systems, field bunding, contour bunding, digging of trenches even on the fields of small and marginal farmers. Digging of farm ponds even for small and marginal farmers should be the high priority of drought adaptations and proofing. Land shaping, levelling of fields, making ridges and furrows or beds and furrows to enhance irrigation and water use efficiency are also permitted in the scheme. Labour for spreading organic manure, mulching to prevent loss of stored moisture could be booked to this scheme.

iii) Micro irrigation scheme: Drought managers may focus on popularizing sprinklers, dripper, fertigation etc.

iv) BRGF: It is an untied fund and has been used generally for civil works of roads etc. However, it could also be considered for implementing drought contingency activities.

v) IWMP: This is about Rs.16,000 crores scheme , common guidelines are available, almost all states have been sensitized in workshops organized by NRAA and its resources can be deployed for managing drought. Livestock based interventions, activities for landless, in situ conservation and harvesting of rain for supplemental irrigation to save crops, farming systems etc. are tremendous opportunities.

vi) NFSM: Alternative contingency cropping of boro rice, wheat, etc. can be considered under these resources.

vii) Artificial groundwater recharging: It is a Rs.1600 crore scheme of the Ministry of Water Resources. There are about 10 million dug wells in the country, about 40% have dried up and can be recharged with these resources. There are also several other ways of recharging ground water which is an important strategy of drought proofing.

viii) AIBP: Lift irrigation schemes, water harvesting by constructing weirs, check dams and conveyance system may be prioritized in the implementation process to alleviate drought stress.

26. Contingent Plan for Rabi 2009

The rainfall is reviving since August 13, 2009 especially in Assam, Bihar etc. Rice transplanting or direct seeding is still possible as one moves to east. Kulthi (horse gram) and fodders like bajra, sorghum and cowpeas can be planned. Other possibilities are described below:

i) In case rains are received before September 10, *toria* and *taramira* should be sown immediately as catch crops. Wherever *toria* and *taramira* seed is not available, Agarni variety of mustard can be grown as replacement of *toria*. If the temperature is high it may effect *toria* and mustard germination. The farmers are advised to check for optimum temperature range for *toria* germination before sowing the crop in their respective regions.

ii) In case rains are received by end of September, mixed sowing of wheat + gram and barley + gram can be taken up in almost all rainfed regions. Mustard inter-cropped with gram in rows about 3 m apart is another option. Lentil is another pulse crop which can be raised with 2-3 irrigations. Vegetable crops such as peas, broad bean, French bean and spice crop fennel can be raised with availability of one irrigation.

iii) In the light of lower availability of surface and ground water for irrigation, the farmers particularly in the Indo-gangetic alluvial plains are advised to resort to zero tillage and strip-till drills wheat cultivation after utilizing the residual moisture available after rice harvest. Zero tilled wheat saves on about 30% water, energy and labour and also gives either equal or enhanced yield compared to conventional tillage. Perfect zero till machines are available in the market. Some budget may be earmarked for supply of such drills on subsidized rate to the farmers. No-till drills and strip-till drills in large numbers should be procured and distributed; and their manufacturing regionalized so that interested farmers or service providers could easily purchase them.

iv) Resorting to bed planting and furrow irrigated system for wheat cultivation wherever feasible and practical. It saves about 30% irrigation water and increases wheat yield. Planting of cauliflower on ridges and tomato on beds to save irrigation water.

v) The area left unsown during *kharif* should preferably be sown with *rabi* fodder crops, oilseeds and pulses.

vi) Need based location specific agronomic manipulations such as application of mulch available locally to conserve moisture, application of P and K as basal dose, reducing N dose and seed rate etc. can be adopted. Special care should be taken for plant protection aspects during drought phase.

vii) Resorting to cultivation of less water demanding crops and cropping systems in limited irrigation water supply areas. Such crops and their varieties can be chosen from the *rabi* contingency plans of respective states. For example, wheat variety WH 157 and WH 283 can be successfully cultivated with limited water in Punjab, Haryana and Madhya Pradesh. Kundan variety of wheat is another such example which has comparatively higher dry matter production efficiency per unit water consumed. Vegetable crops such as garden pea (Arkel, Pragati), winter bean and vegetable mustard are the examples requiring less irrigation water.

viii) Rotavators are efficient tillage equipments for preparing fine seed bed in 1-2 phases saving time and energy used in seed bed preparation, especially crops that need fine tilth. Since in dry farming time available in seed bed preparation and sowing is limited, large sized tractors with matching implements be used for carrying out different farm operations which should be available through custom service. Seed-cum-fertilizer drills/multi-crop planters should be available for sowing different crops during *rabi*. In eastern India, *Utera* (broadcasting rabi crop seed in the standing rice crop) after rice should be replaced by drilled crop using zero-till drill or other seed-cum-fertilizer drills that can work. For timely harvesting and threshing of crops in the fields, vertical conveyor reapers for harvesting and high capacity multi-crop threshers and combines are needed on custom hire. This would help in timely clearing of fields and sowing next crop.

27. Epilogue

i) Weather related calamities adversely impact livelihood and economies of large population in the rainfed, arid and semi-arid regions. Intensity and frequency of extreme weather events is likely to increase due to global warming and climatic changes. Any long term planning for drought management must be based upon strategies which take into account livelihood opportunities and support system both in irrigated and rainfed areas.

ii) Droughts cause misery to humans, livestock, wild life and bio-diversity, accelerate degradation of natural resources and put a heavy burden on state exchequer. Excessive use of energy, fast depletion of ground water resources, declining per capita resources availability, risks, and extreme distress of farmers

are alarming emerging trends. A future vision of drought beating strategies will require re-orientation from cropping system based approach to farming system based on-farm participatory approach, from annual arable cropping based to perennial multipurpose trees based strategy, shift from, maximum production concept to optimum production targeted at reducing cultivation cost and conservation of resource base, food-fodder-feed-fuel cropping system to food-fodder-fuel concept targeted at sustenance of livestock related issues.

iii) Problems of tackling drought impacts are complex and multifaceted. Strategies to deal with these problems therefore require (a) multi-institutional and multi-disciplinary resource building approach with farmer at centre stage, (b) current status and effectiveness of drought mitigation and desertification control strategies and re-orientation required to make them effective and (c) fixing short and long-term priorities focusing on overall improvement of ecology of drought prone areas.

iv) Compensatory production to utilise opportunities of good rainfall in other states/regions/districts to cover production loss in the drought affected areas.

v) Several innovative, flexible and decentralized opportunities of NREGS, RKVY and IWMP exist to convert weaknesses into strengths

vi) Harmonization of recent technologies, IT and e-chaupal based extension services and emerging demand of accelerated GDP growth rate is called upon.

Annexure 1

Date Bound Crop Contingency Plan for Rainfed Regions

S.No.	IMD/Agro-eco region	Crop Plan		
		15-31 July	1-15 August	16-31 August
1	2	3	4	5
1.	IMSD: Plains of Western UP AER: 4.1 MPS: pearlmillet/ Rapeseed and Mustard AD: Agra, Mathura, Aligarh, Bulandshahar, Meerut Etah, Mainpuri and western part of Muzaffarnagar.	• Medium to short duration verities of rice Pant 4, Pusa-44, ND 97, Sarju-52 etc. • Medium duration maize like Tarun, Naveen & Prakash. • Pearlmillet, (Pusa-23, Pusa-322, WCC-75), green gram, short duration pigeonpea. Vegetable type cowpea and clusterbean	• Early duration rice, maize & pearl millet. • Where pearlmillet, fails, take clusterbean, green gram and cowpea. • Direct seeding of rice (Govind, ND-118 & 97) • Cowpea and clusterbean (vegetable type)	• Clusterbean, cowpea, toria (Bhawani, PT30) • Jowar, Bajra, maize, Lobiya, fodder
2.	IMSD: Plains of Western U.P. AER: 4.4 MPS: Jhansi, Banda, Hamirpur, Lalitpur, Morena, Gwalior	• Medium duration rice like surju-52, NDR-359 • Bajra, guar, cowpea, lablab bean, early pigeonpea and black gram as grain crops	• Early maturing rice like Saket-4, Govind & Ashwani • Direct seeding of rice • Bajra, guar and cowpea as grain and fodder. • Pigeonpea, moong (Pant-1, Samrat), Urd (Pant U-35, U-19, T-9) as grain crops	• Bajra, guar and cowpea as fodder, toria (Bhawani) • Prepare filed for Rabi
3.	IMSD : Eastern U.P. AER : 9.2 MPS : Rice/Pearlmillet AD : Varanasi, Mirzapur, Jaunpur, Ghazipur, Sitapur, parts of Shahjahanpur, Lucknow, Barabanki, Rai Baraeli, Sultanpur	• Medium to short duration varities of rice, maize, pearlmillet & Sorghum • Rice varities Sita, Sarju-52, NDR-97, 359 & Pant-4. Variety CSR-10 & 13 for salt affected soils • Maize varieties Prakash, Sartaj, Naveen &	• Green gram, black gram, early pigeonpea, sesame, niger • Short duration rice varieties with old seedling and/or direct seeding (NDR-80, 97, NDR-118). • Vegetable type cowpea, guar and lablab bean • Short duration maize, pearlmillet & Sorghum	• Green gram, (Bahar, Pusa-9 & DA-11), pigeonpea & Niger • Fodder sorghum, maize, Jowar, Lobiya, Gaur single or mixed cropping • Prepare fields for toria(Bhawani, Panchali), potato, Sarson

IMSD: IMD Sub-Division
AER: Agro-Ecological Region
MPS: Major Production Systems
AD: Area Domain

		Tarun; Pearl millet: Pusa-23, 322 & WCC-75; Jowar-CSB-13&15; CSH-16 • Intercropping and/or mixed cropping in long duration Pigeonpea with maize, urd, moong etc. • Green gram (T44, Pant moong 1), black gram (T9, Pant Urd 19, 35, Narendra Urd 1), early maturing pigeonpea (Bahar and Narendra Arhar 1), sesame (T-4, T-12, T-13). • Vegetable type cowpea, lablab bean and guar	• Maize/Sorghum far fodder where rice transplanting not possible.	etc.
4.	IMSD : Bihar AER : 9.2 MPS:Rice- heat/Maize Rice –Sugercans Rice –Potato +ming AD : all districts	• Transplanting of rice seedlings of medium to long duration HYV varieties with higher plant population. • Sowing of Maize composite varieties, Urd, Mung, Cowpea, Arhar, Kulthi and Mishrikand in upland. • Direct seeding of early duration (110-	• In uplands urd (Navin and T9), Moong (T44, PDM 44), Arhar (Bahar, Pusa 9 and Narendra Arhar 1), Kulthi (DV 7, BR 5, BR 10, S67/26, 14, 31) and Mishrikund (Local) • Early to extra early duration rice varieties through direct seeding Drum seeders can be used for direct sowing of sprouted seeds. • Rice seedling	• In uplands and midlands, sowing of urd (Navin), Arhar (Bahar and Pusa 9), Mung, cowpea, Mishrikand and toria (RAUTS17, Panchali) • Extra early duration (75 to 85 days) rice varieties like Turant dhan and Prabhat direct seeded in midlands.

		120 days) rice varieties like Prabhat, Saket 4, Dhan Laxmi, Saroj in midland. • Nursery sowing of early duration and photosensitive rice varieties by dapog method for transplanting in midlands and lowlands, respectively. • Transplanting of photosensitive rice varieties in rainfed lowlands @ 30 hill/m^2 with recommended dose of NPK (50:20:10) • Sesame & Castor in uplands in districts like Gaya, Nawada etc.	upto 40 days age of medium and 50 days old for long duration HYV rice varieties may be transplanted @40 hills/m^2. • In rainfed lowlands transplanting of photosensitive rice varieties. • Fodder maize & fodder sorghum	• Close planting (40-45 hil/m^2) of long duration HYV rice varieties upto 55 days old seedlings in lowlands. • In rainfed lowlands, photosensitive rice varieties upto 65 days old seedling @40-45 hill/m^2. • Double transplanting of rice (kharuhan) with 30 + 45 days old seedling of long duration or photosensitive varieties. • Vegetables like cucur betacy, bhindi, brinjal, tomato, pea. • Fodder maize, fodder sorghum & napier.
5.	IMSD : Jharkhand AER : 11 & 12.3 MPS : Rice, Mollets AD : All districts	• Transplanting of medium to short duration rice in low lands on receipt of rains. • Direct seeding of short duration rice in medium up lands (Birsa Vikas Dhan). • Short duration maize, urd & soybean in uplands. • Vegetables like	• Direct seeding of rice. • Transplanting of rice seedlings in low lands with higher plant population. • Growing of niger, kulthi, black gram, maize in up & mid lands. • Cowpea, radish & vegetables. • Fodder sorghum & fodder maize.	• Kulthi, niger, fodder maize & fodder sorghum • Pre-rabi oil seeds.

		Bhindi, tomato, French bean, cowpea etc.		
6.	IMSD: Haryana, Chandigarh & Delhi AER: 2.3 MPS: Pearlmillet-Rapeseed/ Mustard AD : Hisar, Bhiwani, Sirsa, Mhaendergarh, Gurgaon & part of Rohtak district	• Short duration bajra (HSB-67) including gap filling when rains • Moong, urdbean (T-9), Cowpea (charodi), guar (HG 365) where paddy transplanting fails • Vegetable type clusterbean and guar • On receipt of good rains, direct seeding of Basmati like CSR 30 & PR 1121	• Transplanting of HSB-67 & HSB-64 variety of bajra as grain crop or direct sowing as fodder crop	• Conserve moisture for toria (PT303, Sangam TL1) sowing.
7.	IMSD: Punjab AER: 9.1 MPS: Maize-rice AD: Submontaneous districts of Punjab, J&K HP and Western UP	• Pearl millet instead of maize in Kandi area. • Black gram, green gram and sesame in kandi area of Punjab. • Complete transplanting of Basmati rice or direct seeding of rice. • Short duration maize, moong, mash as grain crops. • Bajra, guar sorghum and maize as fodder crops. • Vegetable cowpea and clusterbean.	• Pearlmillet, Moong and mash. • Bajra, guar and maize as fodders. • Sunhemp or Sesbania as green manure. • Vegetable type clusterbean and cowpea.	• Jowar, Bajra, guar, maize, cowpea as fodder crops • Toria (PT303, TL15, PBT37) and other vegetables.
8.	IMSD : Himachal Pradesh AER : 14.1 & 14.2 MPS : Rice, Miaze, vegetables AD : All districts	• Re-sowing of maize. • Sowing of rajmah, urd, beans etc in low & mid hills. • Growing of vegetables like Bhindi, tomato, khira, bitter gourd	• Sowing of urd, beans, mandua, rajmah, kulthi, peas in unsown area under maize & paddy. • Fodder maize & sorghum. • Vegetables	• Sowing of toria, oil seeds. • Fodder maize & sorghum

9.	IMSD: Assam & Meghalaya AER : 15.2. &15.4 MPS : Rice, cash crop AD : All districts	• Transplanting of very early maturing rice varieties like Luit, Lachit, Govind, IR-50, IR-36 and Jaya etc. • Photo sensitive variety Gitesh	• Direct seeding of Sali rice on puddled soil with sprouted seeds. • Rice varieties - Luit, Kapilee & Disang. • In upland and medium land where rice could not be taken, grow black gram and green gram upto August end. • Growing of vegetables, fodder maize, sorghum	• Direct seeding of rice varieties (Luit, Kapilee and Disang) • Sowing of black gram varieties - Saoniah mah (SB121), KU301 and USJD113. • Sowing of Green gram varieties – Pratap(SG-1), SG-21-5. • In unsown area, sowing of toria (Panchali, PT 303) as catch crop • Fodder crops & vegetables
10.	IMSD : Western MP AER : 5.2 MPS : Soybean, Sorghum AD : Indore, Ratlam, Ujjain, Dewas, Dhar, Khandwa, parts of Sehore	▪ Sowing of Soybean (JS-9560), Short duration maize, Pigeonpea (ICPL 151, ICPL 88039) in deep soils. ▪ Sunflower, Sesame, Cowpea, Castor. ▪ Sorghum, Dinanath grass and bajra as fodder crops.	▪ Sunflower, sesame, cowpea, castor ▪ Sorghum, Sudangrass, maize, Dinanath grass and bajra as fodder.	▪ Safflower, sunflower, sesame (RT 46); castor. ▪ Maize as fodder crop
11.	IMSD : East M.P. AER: 10.1. & 10.3 MPS : Rice & Soybean AD :Balaghat, Chatarpur, Damoh, Jabalpur, Rewa, Sagar, Satna, Tikamgarh,	• Early maturing varieity of soybean (JS 9560, 9305), maize, pigeonpea etc. • Transplanting of rice • Vegetables like Bhindi,	• Black gram (T 9), green gram (K-851) & sesamum (JT-7, Jawahar sesamum 21) with proper drainage in black soils • Fodder maize	• Fodder maize, toria (jawahar toria -1, T-9) as catch crop

	Shahdol, Panna	gourd , onion.		
12.	IMSD : Madhya Maharashtra AER : 6.1 MPS : Rabi sorghum AD : Sholapur, Bider, Osmanabad, Ahmednagar, parts of Satara, Latur and Sangli	• Sowing of soybean, bajra (sharda), pigeonpea (BSMR-736), sunflower (SS-56), castor, kulthi as single and intercropping like pigeonpea + sunflower, pearlmillet + pigeonpea	• Sunflower, pigeonpea, castor, bajra & ragi • Intercrop of castor + Tur, Bajra + Tur, Sunflower + Tur	• Sunflower, pigeonpea, castor, castor + Tur • Fodder sorghum
13.	IMSD : Vidarbha AER : 6.3 MPS : Cotton/sorghum AD : Akola, Warda, parts of Amravati, Yeotmal, Parbhani, Buldana and Khandesh and parts of Adilabad of A.P.	• Sunflower, castor, Soybean (JS335) • Intercropping of pigeonpea + Soybean, Pigeonpea (Asha), pearlmillet, maize,	• Pigeonpea, pearlmillet, maize, sunflower, castor. • Early duration varieties like pigeonpea ICPL 87119 & 8863, cotton AKH081 and Soybean JS 335, TAMS98-1	Pigeonpea, castor, Reserve the land for rabi safflower
14.	IMD : Rayalaseema AER : 3.0 MPS : Groundnut AD : Anantapur, Kurnool, Chittoor districts of A.P.	•Groundnut, (Narayani) + redgram	•Groundnut (Narayani) •Early maturing castor varieties/hybrids DCH519, Jwala (48-1), Kiran, Kranti etc.	•Dual purpose sorghum, horsegram & sunflower
15.	IMSD : Gujarat, Daman, Dadra and Nagar AER : 4.2 MPS : Pearlmillet AD : Khera, Gandhinagar, Mehsana, Sabarkanta, parts of Ahmedabad Panchmahal, Banaskantha and Vadodara districts.	• Clusterbean (Guj clusterbean-1), castor, sesamum (GT-1), fodder sorghum (S-1049)	• Thinning of already planted crops. • Castor and fodder sorghum • Short duration pulses like green gram (K-851)	• Castor, fodder sorghum, fodder sorghum + karingada

16.	IMSD : Saurashtra, Kutch and Diu AER : 2.4 MPS : Pearlmillet/Groundnut AD : Rajkot, Sundergarh, Jamnagar, Parts of Junagarh, Bhavnagar and Amreli	Erect groundnut; sesame; hybrid bajra; green gram (K851); blackgram (T9); pigeonpea	Blackgram (T9); forage maize/sorghum, Castor; sesame	Forage maize/sorghum, sesame
17.	IMSD : Jammu and Kashmir AER : 14.2/14.3 MPS : Maize AD : Jammu, Punch, Riasi, Muzzafarbad, Udhampur, Kathua	• Bajra, urd, cowpea, moong (direct sown), bajra (transplanting) • Transplanting of rice varities IET-1410, Jaya/RR-8585 @ 4-5 seedings/hill	• Bajra + cowpea/guar (fodder) Jowar + cowpea/ guar (fodder), maize + cowpea/ guar (fodder)	• Fodder bajra, cowpea, Jowar, maize • Preparation for September sowing of toria, gobhi sarson
18.	IMSD : Eastern Rajasthan AER : 4.2/2.1 MPS : Maize/Pearlmillet AD : Bhilwara, Tonk, Dungarpur, Ajmer, Chittaurgarh, Rajasamand, Jalore, Sikar, Jodhpur, Churu	• Short duration varieties of sesame (RT-46), green gram (K 851, T 9), clusterbean (RGC-936), horse gram (AK-21). • Sorghum and cowpea as fodder. • Snapmelon and mateera as vegetable crops	• Short duration Sesame (RT-46), green gram (T-9), sorghum and cluster bean (RGC-936)	• Fodder Sorghum, *toria(T9)*, *taramira*
19.	IMSD : South interior Karnataka AER : 8.2 MPS : Fingermillet AD : Bangalore, Kolar and Tumkur	• Sowing of pigeonpea (HYD-3C, TTB-7), groundnut (TMV-2, DH-330), Finger millet (Indaf-8 & 9, HR-911, PR-202, MR-1) and maize (NAC-6002, Deccan-103 & ganga-11) as single/	• Sowing of medium duration varieties or transplanting/ Sowing of short duration varieties as nursery, Sunflower hybrids, Cowpea and soybean. • Transplanting of chillies Maize. • Sorghum, bajra as fodder crop	• Transplanting of short duration varieties of pigeonpea, Cowpea, horsegram. • Transplanting of chillies if protective irrigation available. • Maize, sorghum, bajra as fodder crops

		intercrops • Sunflower hybrids, castor, soybean, chillies		
20.	IMSD : Orissa AER : 18.4 MPS : Rice AD : Uplands and medium lands of Balasore, Cuttack, Puri and Ganjam	• Sowing of pigeonpea (T-21, ICPL 87), maize, cowpea (SGL-1), finger millet, groundnut, black gram and green gram in uplands. • Paddy in low and medium lands including short duration varieties through direct seeding. • Short duration radish, okra, cowpea and clusterbean as vegetables.	• Niger, blackgram, radish, beans and cowpea as vegetables • Castor, early pigeonpea • Direct line sowing of extra early rice in low lands.	• Horsegram, sesame, Niger, cowpea and Toria (Anuradha & Parbati) in uplands. • Land preparation for sowing of pre-*rabi* crops like mustard/ greengram/ early pigeonpea in medium lands
21.	IMSD : Gangetic WB AER : 15.1 MPS: Rice, Maize, wheat	• Transplanting of aman rice & direct seeded early rice • Pulses, urd, moong etc in uplands	• Fodder sorghum, maize • Vegetables	• Toria (Agrani & panchali) as catch crop in unsown area of gangetic plains • Fodder maize & sorghum

Annexure-2

List Of Early Maturing Crop Varieties

Crop	Varieties	Area of Adoption
Groundnut	JGN-3	Madhya Pradesh
	K 134	Andhra Pradesh
	ICGV 91114	Andhra Pradesh
	Kadiri 6	Andhra Pradesh
Mustard	Pusa Bahar, ,	Assam, Bihar, Orissa,West Bengal,
	JD-6	Bihar, Orissa, West Bengal, Jharkhand, Assam
	Shivani (BAUR 9502)	Jharkhand
Soybean	NRC 7	Madhya Pradesh
	JS 71-05	Madhya Pradesh
Chickpea	RSG 888	Haryana, Punjab, Rajasthan, Jammu, Western UP, Uttaranchal, Delhi.
	RSG 963	Haryana, Punjab, Rajasthan, Jammu, Western UP, Uttaranchal, Delhi.
Lathyrus	Bio L 212	Eastern UP, Bihar, Jharkhand, West Bengal, Assam
Moth bean	Cazri Moth 3	Rajasthan, West Bengal, Gujarat, Haryana
Horse Gram	AK 21	Rajasthan, West Bengal, Gujarat, Jharkhand, Himachal Pradesh
Guar	RCG 936	Rajasthan, Gujarat
Pearl millet	HHB 67-Improved	W.Rajasthan, Gujarat, Haryana
	GHB 538	W.Rajasthan, Gujarat, Haryana
	HHB 94	Haryana
	HHB 197	Rajasthan, Gujarat, Haryana, U.P., M.P.
	GHB 732	Rajasthan, Gujarat, Haryana, U.P., M.P.
	GHB 744	Rajasthan, Gujarat, Haryana, U.P., M.P.
	GHB 757	Rajasthan, Gujarat, Haryana
	GHB 719	Rajasthan, Gujarat, Haryana
	RHB 121	Rajasthan, Gujarat, Haryana, M.P.
	Saburi	Maharashtra, Karnataka, Gujarat, Tamil Nadu
	GHB 558	All India
	HHB 117	Haryana
	MP 443	Rajasthan, Gujarat, Haryana
	CZP 9802	Dry areas of Rajasthan, Gujarat, Haryana
	HC 10	Haryana
	JBV 2	Haryana, Gujarat, U.P., M.P.
Sorghum	CSV 17	Rajasthan, Madhya Pradesh, Uttar Pradesh, Gujarat, Maharashtra, Karnataka, Andhra Pradesh & Tamil Nadu
	CSH 23	Rajasthan, Madhya Pradesh, Uttar Pradesh, Gujarat, Maharashtra, Karnataka, Andhra Pradesh & Tamil Nadu
Finger Millet	Indaf-9	Karnataka
	GPU-26	Karnataka
	GPU-45	Gujaraj, Jharkhand, Karnataka, Madhya Pradesh & Maharashtra
	GPU-48	Karnataka
	VL-149	All states
	VR-520	All states
	KM-65	Uttar Pradesh

	VR-708	Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Karnataka & Orissa
	PR-230	Andhra Pradesh
	BM-9-1	Karnataka, Andhra Pradesh, Orissa, Madhya Pradesh & Maharashtra
	KM-13	Uttar Pradesh, Madhya Pradesh & Orissa
	PES-400	Hills of Uttar Pradesh
	Indaf-9	Karnataka
Foxtail Millet	K-3	Tamil Nadu
	TNAU-43	Tamil Nadu
	TNAU-186	Tamil Nadu, Andra Pradesh and Karnataka
	TNAU-196	Tamil Nadu
	AK-132-1	Andhra Pradesh
	Krishna Devaraya	Andhra Pradesh
	Sri Lakshmi	Andhra Pradesh
	Godavari (SR-11)	Rajasthan
	Prathap Kangani 1 (SR-1)	Rajasthan
	Meera (SR-16)	Rajasthan
	PS-4	All states
	PRK-1	Uttar Pradesh
Kodo Millet	GPUK-3	All States
	JK-76	Madhya Pradesh and Chattisgarh
	JK-62	Madhya Pradesh
	APK-1	Tamil Nadu
	KMV-20	Madhya Pradesh, Karnataka and Chattisgarh
Barnyard Millet	Sushrutha (RAU 11)	Karnataka
	Kanchan	Uttar Pradesh
	VL Madira 172	Uttar Pradesh, Gujarat and Karnataka
	VL Madira 181	Bihar, Karnataka, Madhya Pradesh, and Tamil Nadu.
Little Millet	Paiyur 1	Tamil Nadu
	TNAU-63	Tamil Nadu, Karnataka and Gujarat
	Paiyur 2	Tamil Nadu
	Tarini (OLM-203)	Karnataka, Andhra Pradesh, Orissa, Bihar and Tamil Nadu
	Kolab(OLM)	Madhya Prades, Orissa, Chattisgharh, Bihar, Karnataka and Gujarat
	OLM-20	Orissa, Madhya Prades and Chattisgharh
	Birsa Gundli	Bihar Plateau, Jharkhand
Proso Millet	K-1	Tamil Nadu
	C0-4	Tamil Nadu
	Nagarjuna	Andhra Pradesh
	Sagar	Andhra Pradesh
	GPUP-8	Karnataka
	GPUP-21	Karnataka, Tamil Nadu
	Bhawana	Uttar Pradesh

Forage Crop Varieties Suitable For Late Sown Condition

Crop	Varieties	Area of adaptation
Pearl Millet	Giant Bajra	Bajra growing tract
	Raj Bajra Chari-2	Uttar Pradesh
Sorghum	UP Chari-1	Uttar Pradesh
	UP Chari-2	All India
	Pant Chari-3	
	Pusa Chari-9	
	Pusa Chari-23	
	MP Chari	
	HC-171	Haryana , UP & MP
	HC-308	
Maize	J-1006	All India
	Vijay Composite	
Guar	Bundel Guar-1	Guar growing tract
	Bundel Guar-2	
	RGC-936	
	HG-365	
Cowpea	Bundel Lobia-1	All India
	Bundel Lobia-2	
	UPC-287	
Dinanath Grass	Bundel-1	All India
	Bundel-2	
Guinea Grass (annual)	PGG-9	Guinea grass growing areas
	PGG-14	

Source: ICAR Website

Annexure 3

Crop-Group and Cropwise Contingency Plan for Kharif Season

Pulses

(i) In the event of late monsoon arrival the pulse crops which can be planted preferably up to 15th August or till 1st week of September are: Blackgram, Greengram, Horse gram (Kulthi), moth bean, peas in hills, Pigeonpea clusterbean and lobia.

(ii) In case of greengram and blackgram all varities recommended for *Kharif* season may be grown up to first week of September. Sowing after first week of September may be done only for the purpose of fodder.

(iii) Only specific varieties of pigeonpea may be grown up to first week of September which are recommended for pre-*rabi* planning. These varieties are Bahar, Pusa 9 and *rabi* Arhar 20(5) for the States of Bihar, W. Bengal, Orissa, Andhra Pradesh, Maharashtra and Gujarat. Planting of early pigeonpea is not possible in States like Punjab, Haryana and Western U.P. where early maturing varities of pigeonpea normally are grown in first week of July.

(iv) Crops like mothbean can be grown for grain as well as fodder till the second week of August in the states of Rajasthan and Gujarat.

Oilseeds

(i) In case of oilseed crops, sesame can be planted up to third week of August whereas niger can be sown upto September. Since the per hectare requirement of seed in case of sesame is very low all out efforts must be made to cover more area under sesame to utilize the land in the event of failure of other *Kharif* crops like maize, *pearlmillet* and other minor millets.

(ii) In traditional areas, where sowing has not been taken up during June and July due to non receipt of rainfall, sowing of castor can be done in Gujarat and parts of Maharashtra, Rajasthan, Chattisgarh and Orissa to take advantage of stored moisture and in rainfed alfisols in Telangana region of Andhra Pradesh in medium/heavy soils till third week of August.

(iii) Similarly, castor can be grown successfully up to first week of September in areas which are suitable for castor cultivation. Early maturing varieties/hybrids of castor DCH 519, Swala (48-1), Kiran and Kranti are recommended for Andhra Pradesh

(iv) The other two important oilseed crops like soybean and groundnut are likely to suffer heavily in case rains are delayed beyond end of July. However, groundnut can be planted up to September as well as summer reason in a few southern states. Therefore, efforts should be made to cover more area under groundnut in the States of Andhra Pradesh, Tamil Nadu and Karnataka.

(v) In traditional sunflower growing areas of Karnataka, Andhra Pradesh and Maharashtra Kharif plantings could be taken up with the receipt of rains in light soils. It is better to plant sunflower late in August and September to avoid necrosis disease.

(vi) Short duration variety of sesame (RT 46), Greengram (T9), Cluster bean (RGC 936) may be grown in Rajasthan.

(vii) Since the rains are delayed, there seems good possibility of coverage for Toria in the States of Punjab, Haryana, Uttar Pradesh, Orissa, Assam, Bihar West Bengal, Uttarakhand, Jharkhand and part of MP. Therefore, greater emphasis is to be given to cover more area under Toria as catch crop. Recommended varieties of Toria are given in **Annexure - 8**.

(viii) Toria, requires a fairly moist seed-bed for good germination, but excessive moisture should be avoided. The sowing of toria could be taken up by the end of August. However, care should be taken to control the incidence of saw-fly and painted hug. In case of excess rainfall, proper drainage of water should be ensured. When the temperature is continuously above 35°C, sowing should be avoided.

Cotton

(i) In the northern zone, cotton crop is grown entirely under irrigated condition and the present spell of drought being witnessed all over the country is not going to have a major impact in the irrigated cotton belt of the northern zone.

(ii) In the event of shortfall in the availability of canal water, it is suggested that the farmers may adopt alternate furrow irrigation which will economize water requirement by nearly 50%.

(iii) Micro-irrigation system such as drip and sprinkler deserves to be promoted wherever feasible and in the event of limited water availability.

(iv) Central zone is mainly rainfed. In this zone, Bt and non Bt cotton is grown mainly as rainfed crop and is subjected to the vagaries of monsoon. Deep black soils are the best bet. In 2009, relatively more area was sown as compared to normal due to early arrival of rains. However, there is a long break in the rains and cotton sown in shallow black soil or red chalka soils may suffer

The following moisture conservation measures are suggested for effective utilization of the available water in the soil as well as the likely precipitation in the remaining part of the season.

(v) Development of ridge and furrow across the slope for effective conservation of soil moisture as well as rainwater.

(vi) Use of organic mulches such as subabul lopping, tree leaves, pine needles straw etc. to conserve the soil moisture.

(vii) Repeated interculture operation to keep the field weedfree.

(viii) Wherever water resources are available such as lake, ponds, wells etc. protective irrigation can be provided to the crop.

(ix) Micro-irrigation system as suggested above may be adopted wherever possible for improving the water use efficiency and to cover more area.

(x) Nutrient input management through foliar application is suggested.

In the central zone short duration varities recommended for respective states by State Variety Release Committee / Central Variety Release Committee may be planted latest by July. Beyond end July, alternative crops such as castor and pigeonpea may be cultivated looking to the local conditions.

The contingency measures suggested for central zone are also applicable for the rainfed areas of south zone especially Andhra Pradesh and Karnataka. In the winter cotton area of Tamil Nadu, sowings are yet to be taken-up.

(xi) Early maturing varieties of G. *hirsutum* such as PKV 081, Rajat, Anjali, I.RA 5166 etc. may also be planted where sowing has been delayed because of continuous drought.

Vegetables

(i) Mulching soil surface with organic material (leaf mould, FYM) and clean cultivation.

(ii) Growing vegetables such as cluster bean, cowpea, lablab bean, radish, peas which can sustain with less amount of water.

(iii) Enhancing cucurbitaceous vegetables by raising nursery in polythene bags followed by transplanting in order to save 2-3 irrigations.

(iv) Sowing/planting cucurbitaceous vegetables adopting hill and channel system to economise water.

Sugarcane

The sugarcane crop is facing severe moisture stress in UP and many other states of the country. Erratic electric supply in western UP and inadequate discharge in canals are other limiting factors. The drought has adversely affected the elongation phase of the crop thus limiting the cane length. If moisture stress continues further, it may prove detrimental both to productivity and quality of crop in the ensuing crushing season. This warrants saving the crop under such situation as far as possible. The following contingency plan for the benefit of the cane growers to protect the crop from complete failure is suggested.

A. Soil Moisture Conservation

(i) The dried lower leaves of the standing cane crop may be stripped and used as mulch in the inter-row spaces of the crop. This will conserve available soil moisture by controlling weeds and cutting down surface evaporation.

(ii) The intercultural operations may be undertaken to create dust mulch to break soil capillaries for checking surface moisture loss.

B. Efficient Irrigation Management

(i) Extensive (light life saving) irrigation over larger cane area rather than intensive (heavy) irritation in limited area may be practiced.

(ii) Adopt alternate furrow irrigation to effect water saving.

(iii) Under limited water availability conditions, irrigations should be scheduled to cover the drought susceptible varieties and ratoon stands in the first instance. Irrigation may be phytophased to avoid soil moisture stress at consecutive critical stages of crop growth stages of crop growth.

(iv) Sprinkler irrigation may be adopted during period of less evaporative demand to maintain optimum soil moisture regime.

C. Crop and Nutrient Management

The crop stands (both plant and ratoon) have already been exposed to moisture stress in the early phase of the crop. Therefore, it would be advisable to adopt the following management practices to save the crop and revive its further growth.

(i) Weed control through herbicides may be taken-up particularly in late planted cane. Where herbicide application is not feasible, the weeds may be cut and used as surface mulch to conserve soil moisture.

(ii) Earthing-up operation could also be taken in autumn and timely planted crops which have attained reasonable height. The furrows may be utilized for light irrigations covering more cane area.

(iii) If moisture stress continues, the sugarcane crop with poor growth failing to form millable canes may be harvested in October to raise ratoon stand from such crop. The harvested material may be used as seed cane for autumn planting and/or feeding to the cattle.

(iv) The last dose of nitrogen meant for elongation phase, if already not applied, may be top dressed only with light irrigation or after rains.

(v) Spray of 2.5% urea with 2.5% KCI or MOP may be useful in areas where some soil moisture is available. This will impart drought tolerance to plants.

D. Plan for autumn planting of sugarcane crop (2009-2010)

(i) The area meant for autumn sugarcane planting should be kept free of weeds and conserve soil moisture to start early planting.

(ii) Autumn sugarcane may be intercropped with short duration high value mid season income generating crops like toria, mustard, peas, spices etc. This will also encourage farmers to go for planting more acreage under autumn sugarcane giving higher cane yield and sugar recovery.

(iii) Winter initiated ratoon of early sugarcane varieties may be intercropped with high density early bulking forage crops like *senji* to protect the

stubble sprouts from cold injury, enhance soil fertility and provide forage to animals.

Pearlmillet

(i) Planting of pearl millet hybrids is not advisable. Even early maturing hybrids like HHB 67 should not be planted beyond end of July.

(ii) Wherever crop has been planted and suffering from moisture stress, the plant population may be reduced and shallow inter-culture (dust mulching) may be practiced.

(iii) The pearl millet may be grown mixed with pulses up to 1st week of August as fodder crop, which may give at least fodder to some extent.

Rice

A. Rainfed

(i) In traditionally rice growing rainfed areas where rains are likely to come late and where a normal transplanted rice crop is ruled out, short duration upland rice varieties or those rice varieties that are suitable for direct seeding either in dry or wet condition and subsequent flooding are recommended by direct seeding. In certain areas, delayed transplanting can be done with older nurseries if these varieties are suitable. Suitable rice varieties for different situations are listed in Annexure 2.

B. Irrigated

(i) Irrigation at 1 to 4 days after disappearance of ponded water in case of rice produces almost similar yields as are obtained with continuous submergence. This practice economizes more than 30% of irrigation water without lowering the rice yields. Farmers may be advised to strictly follow this irrigation schedule for already transplanted rice crop.

(ii) Last irrigation to paddy can be terminated 14-17 days before harvest. This saves about 16 cm of irrigation water without any yield reduction. Farmers need to be made aware of this practice well in advance as the short duration early maturing paddy varieties are likely to mature by end of August. The irrigation to such varieties may be withheld beyond August 15 and the same water can be effectively used for main season planted varieties.

Small Millets

A. Rayalseema region of Andhra Pradesh, parts of Karnataka and Maharashtra

Foxtail millet is one of the choice crops of these regions in view of its drought tolerance, freedom from major pests and diseases, photo insensitivity and assured modest yield. For fox-tail millet in Andhra Pradesh, Karnataka and Maharashtra, application of 40:30:0 kg NPK/ha as basal dose for achieving quick growth and withstanding drought is recommended.

B. Western Rajasthan

Foxtail millet (knagni) a well known drought hardy crop can give reasonable harvest in areas where annual rainfall is less than 400 mm. Varieties of fox-tail millets, viz. SR 11 (Gauri) and SR 16 (Meera) are suitable for delayed planting and mature in 80 days. SR 16 has stay green character and gives higher fodder yield also. Application of 10-20 kg N/ha as basal dose is beneficial in withstanding drought and giving higher yield.

C. Gujarat

Small millets are not important in the state except in the region of Dangs and adjoining areas. In years of extreme drought and erratic monsoon small millets like kodo, proso and little millet could be ideal crops for contingency planning for producing quickly fodder and grain.

D. Madhya Pradesh and Chhattisgarh

Little millet (kutki) is one of the important crops of tribal areas of Madhya Pradesh and well known for early maturity and resilience. Kodo millet is another crop grown extensively in these states and popular in tribal areas. Kodo millet varieties viz JK-76 matures in 80-85 days and RBK 155 mature in 90-95 days. Application of 10-20 kg N/ha as basal is beneficial.

Sorghum

In case there is delay in monsoon by 2-3 weeks, short duration cultivars such as CSH 6 and CSH 14 can be preferred. In case of staggered planting where some farmers have already sown and others did not, increase seed rate to an extent of 1.5 times of the recommended rate and application of 20 kg of carbofuran or phorate (3 g) granules in the seed rows before sowing are recommended to safeguard against the anticipated shoot-fly attack. Other shoot-fly control measures (spraying of endosulphan 2 ml/litre of water after sowing) can also be followed if soil application is not adopted.

Miscellaneous

(i) Farmers may ensure enhanced fodder availability in view of prevailing dry monsoon. For this, farmers can grow crops like sorghum, pearl millet, small millet, green gram etc. Under this situation, even if there is early withdrawal of rain, at least fodder could be used.

(ii) The quantum of precipitation and its scanty distribution is also going to adversely effect the likely seed availability in the next kharif season. Contingency arrangement for adequate seed production should be made so that it can be made use in kharif 2010.

(iii) In case of good moisture in Uttarakand , fields with existing poor crop growth can be resown with crops like amaranth (VL Chua 44), buck wheat (VL Ugal 7), okra and French bean.

(iv) In certain states early duration paddy, maize and sorghum harvesting is likely to start by September end. The harvested paddy straw and other

biomass need to be enriched and fortified and compact feed blocks need to be prepared. Such fortified fodder/feed blocks containing dry/green roughage, concentrates/ unconventional supplements in the ratio of 50:50 be prepared and stored. Fortified blocks are compact, easy to handle and transport.

(v) Frequent intercultural operation should be adopted for moisture conservation in standing cotton crop.

(vi) Tractor mounted zero till drill can be used for sowing of coarse cereals and pulses without carrying out tillage operation. This will obviate further delay in sowing of the crops, as the time taken for seed bed preparation can be saved.

(vii) In order to cover large area in available time for sowing of coarse cereals and pulses, tractor mounted seed cum fertilizer drills and planters should be used

Suitable trees, grasses and crops for Agro-forestry systems in various agro-ecological regions are given in **Annexure-9**.

Annexure 4

Contingent Plan Relevant to All Crops and Cropping Systems

A. Special package of practices

(i) Making fields free of weeds for full utilization of water and nutrients by the crops.

(ii) Reduction of plant density: In case of mid season moisture stress the crops should be suitably thinned out or rationed in case of sorghum. If moisture stress occurs at very early stage, it is always better to re-sow with subsequent rain rather than allowing sub-optimal poor plant stand to persist. It happened in maize in HP in 2009.

(iii) For anticipating prolonged dry spells the practices of inter-row cropping help in risk sharing. This can be achieved by including a companion crop like green gram, cowpea than the main crops like sorghum or pear millet.

(iv) The recommended dose of nitrogen application should be reduced by 40% under unirrigated conditions and should always be applied at sowing/planting.

(v) Full recommended dose of P and K should be placed as basal dose.

(vi) Resort to maximum possible use of organic bulky manures.

(vii) Recommended plant protection measures to be adopted for kharif millets and pulses.

(viii) Seed of sorghum, pigeonpea, mung bean, cowpea, groundnut, sunflower and castor must be treated with Thiram or Captan @ 2-2.5 g/kg seed.

B. Soil and Water Management Practices

(i) Strengthen the field and contour bunds for in-situ moisture conservation.

(ii) Seed beds to be kept ready so as to facilitate sowing immediately with the onset of rains. Fields should be properly leveled for uniform water distribution within the sub-plot.

(iii) Broad bed and furrow, ridge and furrow, compartmental bunding and contour trench land configuration may be adopted in shallow alfisols as moisture conservation.

(iv) Furrow sowing of *kharif* crops at closer plant to plant distance with wider inter row spacing.

(v) Frequent inter culture to facilitate effect of loose soil as dust mulch.

(vi) Wherever economically viable, mulching should be practiced in between crop rows using locally available mulch material.

(vii) Wherever possible runoff may be harvested in on farm ponds/ reservoirs to make provision for protective irrigation at critical stages.

(viii) Place major emphasis on in-situ rain water conservation, harvesting of excess runoff for re-use and ground water recharge.

Soil and Water Conservation measures for different rainfall regions are given in **Annexure-10**.

C. Irrigation Water Saving Practices

(i) Reduction of conveyance losses while irrigating the light textured soils. A simple and cheap technique is to spread a polythene sheet in the field channel before irrigating the field and then roll it back for irrigating the other field.

(ii) Wherever possible the crops should be sown on ridge and irrigate every alternate furrow on rotation.

(iii) Conserve rainwater by increasing bund height. In case a rainfall of about 3-5 cm occurs near to irrigation date, the irrigation may be avoided.

(iv) Lighter irrigation may be applied during initial growth stages when root growth is limited.

(v) In hard rock areas, for improving well yields, long and continuous pumping should be substituted by intermitant pumpage.

(vi) Adopt recommended water management practices.

(vii) Wherever feasible, adopt micro-irrigation to save water

(viii) Promote measures for enhancing ground water recharge.

Annexure-5

List of state-wise varieties/hybrids for boro/summer rice cultivation

State	Varieties
West Bengal	IR 64, IR 36, Krishna Hamsa, Khitish, Gotra-1, PHB 71, KRH 2, CNRH 3, JKRH 401, DRRH 2
Bihar	Gautam, Prabhat, Mahsuri, Saket 4, Pusa 2-21, Pusa 33, IR 64, PHB 71
Tripura	TRC, Boro dhan 1, KRH 2, DRRH 1, DRRH 2
Orissa	CR Boro Dhan 2, Satya Krishna, Lalat, Parijat, Khandagiri, PHB 71, Geetanjali, Rajalakshmi
Meghalaya	IR 36, Megha Rice 1 & 2, Vijaya
Eastern Uttar Pradesh	Prabhat, NDR 97, NDR 359, Gautam, DRRH 2
Assam	Joymoti, Vishnu Prasad, Jyoti Prasad, Krishna, Mahsuri, Mala, Sujata & Sita

Annexure-6

Technology for Rabi/summer Rice in Boro cultivation area for compensatory losses in production of main kharif season.

Nursery Management	▪ Raise nursery near lift irrigation points and other water sources in the middle of December. ▪ Prepare 1-1.5 m wide raised nursery beds of convenient length with provision of drains of 30 cm width between the beds. ▪ Select good seeds and treat the seeds with Carbendazim (Bavistin) @ 2g/kg of dry seeds after soaking in water for 24 hours. ▪ Sow sprouted seeds on the nursery beds using a seed rate of 30-35 kg/ha. ▪ Apply fertilizer at the rate of 100 kg N, 20 kg P_2O_5 and 20 Kg K_2 O with sufficient FYM/ compost for 1 ha nursery for getting healthy seedlings. ▪ Keep the nursery beds moist for first few days and maintain a shallow layer of water after the seedlings are about 2.5 cm high. ▪ Apply carbofuran (Furadan 3G) @ 1 kg a.i./ha at 15 days after seed germination.
Land preparation	▪ Prepare the land well by using tractor drawn implements in dry condition. ▪ Irrigate the field and then puddle the soil twice followed by laddering ▪ Give a gap of at least 7-8 days between initial and final puddling for better weed control and nutrient availability. ▪ Perfect levelling is must for efficient water management.
Stand establishment	▪ Timely planting is important for higher productivity. ▪ Planting by mid January with 15cm X 15 cm produces higher yield. ▪ 20-25 days old seedlings should be transplanted in puddled land with 2-3 seedlings per hill. Gap fill after 7 days of planting.
Fertilizer management	▪ Apply NPK @ 120:60:60 kg/ha. Soil test based fertilizer application especially for P and K is preferable. ▪ Apply half of total N, entire amount of P and three fourths of K as basal after draining out the standing water but before final pudddling. Top dress the remaining N in two equal splits each at 3 weeks after transplanting and at panicle initiation. Also apply remaining one fourth of K at panicle initiation. ▪ For better soil health apply nitrogen in the form of both organics (green manure, FYM, Azolla etc.) and chemical fertilizer (Prilled urea) in 50:50 proportion. ▪ Apply $ZnSO_4$ @ 25 kg/ha in Zinc deficient soils.

Weed management	▪ Pre-emergence application (7 days after planting) of butachlor (1 kg a.i./ha), thiobencarb (1 kg a.i./ha), pretilachlor + safner @ 0.4 kg a.i./ha and anilofos @ 0.6 kg a.i./ha to effectively control weeds. ▪ Alternatively, hand weed twice at 20 and 40 days after transplanting. ▪ Maintain 3-5 cm of standing water in the field at the time of herebicide application for ensuring effective weed control.
Water management	▪ Efficient water management practices facilitate proper tillering, efficient use of applied nitrogen and reduction of weed infestation. ▪ Field should be kept under saturated condition for a week after transplanting for establishment of roots and stimulate growth of roots. ▪ Afterwards follow the Alternate Wetting and Drying (AWD) method of water management till flowering and maintain a water level of 3-5 cm for about one week during the flowering. ▪ Field should be drained prior to top dressing of fertilizers and irrigate after 24-36 hours. ▪ Drain out water after 15 days from the milk formation stage. ▪ Water saving technologies like SRI, aerobic rice and AWD should be adopted.
Insect pest & disease management	▪ Protect the crop from insect pests and diseases with regular monitoring of pest attacks and by following need based pesticide application. ▪ While spraying pesticides, use 500 lit of water/ha in case of power sprayer. Keep the field bund clean to minimize disease and pest attack.
Harvesting, drying & storage	▪ Harvest the crop when 80% of the grains in panicles are ripened. ▪ Thresh immediately after harvesting and dry gradually under shade up to 12% moisture content for seed purpose and 14% for milling

Annexure-7

List of Rabi Maize growing districts in India

Bihar – Purnea, Katihar, Madhepura, Saharasa, Muzaffarpur, Samastipur, Vaishali, Begusarai, Khagaria, Bhagalpur, West Champaran, East Champaran, Jamui, Sitamarhi, Madhubani, Darbhanga, Ararya, Kishanganj

Uttar Pradesh – Deoria,Gorakhpur,Balia,Chandauli,Varanasi,Bahraich,Gonda, Sravastik,Kanpur,Mahoba,Kannauj,Fatehpur,Lalitpur

Orissa - Nawrangpur,Barjarh,Sambalpur,Khurda,Bhadrak,Mayurbhanj, Keonjhar,Jajpur, Najafgarh

West Bengal - Kooch Bihar,Jalpaiguri,Maldah,Mursidabad, Nadia, Medinapur, Birbhum,Bardhman,Dakshin Dinajpur (South)

Andhra Pradesh – Karimnagar, Nizamabad, Karnool, East Godavari, West Godavari, Guntur, Krishna, Prakasham, Rangareddy, Warangal

Tamil Nadu - Maize is grown in 28 districts except Kanyakumari and Nilgiri Hills

Maharashtra – Kolhapur,Sangli,Pune,Aurangabad, Nasik, Jalgaon, Solapur

Madhya Pradesh – Chhindwara,Baitul,Ratlam,Mandsaur,Indore

Karnataka – Belgaum,Bagalkot,Dharwad,Gadj

Chhatisgarh – Ambikapur,Raigarh,

Gujarat – Panchmahal,Dahod,Vadodara, Kheda,

Rajasthan - Banswara

Annexure-8

Promising Varieties of Torai for Different States

S. No.	Variety	Year of notification	Maturity (Days)	Recommended for the states	Special characteristics
1.	Agrani	1982	70-75	West Bengal	Suitable for rainfed and irrigated areas
2.	Anuradha	2002	75	Orissa	For rainfed areas.
3.	Bhawani	1986	75-80	Uttar Pradesh	Suitable for Irrigated areas
4.	Jawahar Toria1	1997	85-90	Madhya Pradesh	-
5.	M27	1978	90-95	Eastern India	Rainfed areas of Assam, Orissa and Tripura
6.	Panchali	1988	80-85	Assam, Bihar, Orissa and West Bengal	Suitable for rainfed and irrigated areas.
7.	Parbati	2001	75	Orissa	For rainfed areas.
B.	PBT37	1996	91	South Western - Districts and Punjab	_
9.	PT30	1987	95-100	Uttar Pradesh	Bhawar of Uttar region Pradesh (Presently Uttaranchal)
10.	PT303	1985	91-97	Assam, Bihar, Haryana, Punjab, Orissa, UP and West Bengal	For irrigated areas.
11.	PT507	1990	82-91	Eastern States of the Country	-
12.	RAUTS17	1990	85-90	Bihar	-
13.	Sangam	1976	105-110	Haryana	Suitable for irriqated areas.
14.	T9	1975	90-95	Arunachal Pradesh, Madhya Pradesh, Manipur, Meghalaya and Rajasthan	For rainfed and irrigated areas.
15.	TH68	1991	95	Haryana	Rainfed areas of Haryana
16.	TL15	1982	85-88	Punjab. Haryana. H.P.	Suitable for irrigated areas.
17.	VLToria-3	2007	145	Uttarakhand	Tolerant to cold spell of mid Altitudes of Uttarakhand

Source: ICAR Website

Annexure-9

Suitable Trees, Grasses And Crops For Agro-Forestry Systems In Various Agro-Ecological Regions

Trees (Fuel/ fodder)	Grasses	Crops
I**. Hill Regions**		
Grewia optiva (Bhimal)	Chrysopogon fulvus (Gorda)	Wheat
Bauhinia variegate (Kachnar)	Eulaliopsis binata (Bhabhar)	Maize
Celtis australis (Khiriks)	Dichanthium annulatum	Pepper
Albiazia chinensis (Ohi)	Hybrid napier	Potato
Morus serrata (Kimar)	Panicum maximum	Peas
Ficus roxburghii (Timla)	Cenchrus ciliaris	Tomato
Toona ciliate (Toon)	Digitaria decumbense	Cauliflower
Pistacia integerrima (Kekkar)	Heteropogon contortus	Beans, Mustard
Ficus palmate (Angiri)		Sesamum
Melia azadarach (Derek)		Taramira
Bombax ceiba (Simul)		
Prunus Puddum (Pazzar)		
Morus alba (Shehatoot)		
II. Alluvial Plain Region		
Azadirachta indica	Diplachne fusca	Sesamum
Dalbergia sissoo	Dichanthium annulatum	Wheat
Acacia nilotica	Chenchrus ciliaris	Taramira
Shorea robusta	Mentha arvensis	Pearlmillet
Eucalyptus hybrid		Mustard
Populus deltoids		Paddy Potato
Sesbania spp.		
Tectona grandis		
Prosopis juliflora		
Casurina equisetifolia		
Terminalia arjuna		
III. Arid and Semi-arid Region		
Prosopis cineraria	Chenchrus ciliaris	Sorghum
Acacia nilotica	Dichanthium annulatum	Pigeonpea
Cacia tortilis	Panicum antidotale	Blackgram
Albizia lebbeck	Chenchrus setigerus	Taramira
Prosopis juliflora	Brachiaria ramose	Safflower
Holoptelea integrifolia	Digitaria adscendens	Pearlmillet
Acacia albida	Dactylocterium scindicum	Castor
Acacia senegal		Cluster bean
Acacia tortilis		Tobacco
Eucalyptus tereticornis		Cowpea
Hardwickia binata		
IV. Tropical Region		
Azadirachta indica	Hybrid napier	Sorghum
Cassia siamea	Chloris burnii	Safflower
Morus alba	Cenchrus ciliaris	Bengalgram

Pongamia pinnata	Dechanthium annulatum	Maize
Tamarindus indica	Stylosanthus hamata	Cowpea
Eucalyptus globules	Cenchrus setigerus	Pearlmillet
Albizia lebbeck	Setaria grass	Pigionpea
Sesbania sesban	Guinea grass	Castor
Acacia Senegal		Cluster Bean
Acacia albida		Horsegram
Hardwickia binata		
Albizia procera		
Prosopis juliflora		
Dalbergia sissoo		
V. Humid & sub-Humid Region	Cenchrus ciliaris	Maize
Eucalyptus tereticornis	Hybrid Napier	Mustard
Acacia nilotica	Gautemala grass	Pigeonpea
Acacia lecophloea	Guinea grass	Safflower
Acacia planiforns	Setaria grass	Cassava
Ailanthus triphysa	Stylosanthes quyanensis	Elephant foot Yarm
Casuarina equisetifolia		Turmeric
Sesbania grandiflora		Phaseolus
Terocarpus marsupium		Paddy
Acacia auriculiformis		Blackgram
Albitia falcataria		Horsegram
Artocarpus heterophyllus		Cowpea
Sesbania aegyptiaca		Niger
Bauhinia purpurea		Groundnut
Gmelina arborea		
Trema amboinensis		
Tamarindus indica		
Mussaendra macrophylla		
Gliricidium sepium		

Annexure-10

Soil & Water Conservation Measures for different Rainfall Regions

Rainfall (mm)	In-Situ Soil conservation Measures	Rain Water Harvesting /Management Measures
Arid (<500 mm)	Conservation Furrows Contour Farming Sowing across slope/ contour cultivation Mulching, Deep Ploughing Inter row Water conservation System Small basins, Dead Furrows	Inter Plot Water Harvesting Small field ponds/tanks Revival of old, neglected and abandoned traditional water harvesting system Khadins
Semi-Arid (500-1000)	Conservation Furrows Contour Farming Compartmental Bunding Runoff Strips Tied Ridges Graded Ridging Mulching Live hedges Ridge and Furrow System Off season tillage on conserved soil moisture Broad beds and furrows Graded border Strips	On-farm reservoirs Pond /Tank – cum- well System Polythene-lined rain water structure (Doba)/Jalkund Revival of old and abandoned traditional water harvesting system Dug-wells/ Dug-cum-bore wells Ground Water recharge measures Recharge of old and abandoned wells Check dams/gully plugs Water Harvesting Structures with Spillways Efficient Conveyance System Supplemental irrigation through cooperative pumping system with flexible PVC pipes Micro-Irrigation (Sprinkler & Drip)System Water Saving Practices
Sub Humid (>1000mm)	Field Bunds Graded Bunds Vegetative bunds Level/graded terraces Contour trenches Chos Inter-plot water Harvesting Raised bed and Sunken system	Micro-catchments / Conservation Bench Terrace Check dams Seepage pits, Sub-surface water collection Water Harvesting Structures with Spillways Efficient Conveyance System Micro Irrigation Systems (Sprinkler and drip) Measures to reduce storage losses Low cost small irrigation devices like Drum/ Bucket Kit, Drip Irrigation etc. Water management/water saving techniques