2010

INSTITUTE FOR
DEVELOPMENT
INITIATIVES, NEW DELHI
And
INDIA WATER PARTNESHIP

DROUGHT MITIGATION MEASURES THROUGH CLIMATE ADAPTATION FOR SECURING AGRICULTURAL LIVELIHOODS IN UTTAR PRADESH

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ACKNOWLEDGEMENTS

This policy document on drought recommendation measures for Uttar Pradesh is the outcome of research and a workshop held at Jhansi with the active participation of scientists, government officials, and representatives of NGOs. The entire project was funded by the India Water Partnership, New Delhi, which is a constituent of Global Water Partnership, Stockholm. Institute for Development Initiatives, New Delhi, acknowledges with thanks the contribution of the India Water Partnerships for making possible preparation of this document through the financial assistance. We are grateful also to the timely support provided by Prof. S R Hashim, Chairperson and Dr. Veena Khanduri, Advisor and Executive Secretary, India Water Partnership.

We would like to acknowledge the participants from the scientific community, and government and non government organizations for actively participating in the deliberations, contributing papers and providing their valuable suggestions for potential drought mitigation measures.

The National Resource Centre for Agroforesty facilitated the conduct of the workshop by providing the venue and assisting in the logistics. Its Director, Dr. S. K. Dhyani took keen interest in the workshop by delivering the key note address and participating in every session. We would like to acknowledge the contribution of NRC, its Director and Dr. S. Gupta and faculty members in contributing to the successful outcomes of the workshop.

We would also like to thank Dr. J.C. Dagar, ADG (Agronomy and Agro forestry),ICAR for agreeing to be the Chief Guest and providing his valuable insights.

We would also like appreciate the labours put in by Dr.P.S. Pathak, formerly Director, IGFRI in conducting the research, coordinating with experts who contributed papers, contributing the important paper on agroforestry and livestock and organizing the workshop. Dr. V.W. Ambekar, formerly Director, Agriculture, Uttar Pradesh also contributed by facilitating discussions in the Government sector and contributing the important paper on Agriculture. Thanks are also due to all the experts who contributed papers, which formed the core resource for the recommendations contained in this document.

Dr. Joseph Viruthiyel
Honorary Director
Institute for Development Initiatives

EXECUTIVE SUMMARY

i) ***The background and rationale:*** Drought is the most recurring natural calamity in the whole of South Asia and specifically in India. Climate change is one of the causative factors for the increasing frequency and duration of drought. Change in the distribution pattern of monsoon rain and prolonged delay of monsoons is bringing new areas, which never before faced drought, into the clutches of this calamity, affecting livelihoods of millions of poor people.

ii) ***A collaborative effort:*** The India Water Partnership, New Delhi, a partner of the Global water Partnership, Stockholm, with its mission to address the issues and challenges of the water resources has been involved in sensitization and capacity building programmes in the sector. As a part of achieving this objective, the IWP engaged the Institute for Development Initiatives (IDI), New Delhi to develop a consensus document on drought mitigation strategies for securing agricultural livelihoods for the State of Uttar Pradesh, in the context of climate change.

iii) ***The Methodology:*** The methodology adopted by the IDI has been to make: (a) a preliminary desk study of the issues involved, (b) organize a one day workshop on the theme with representation from subject matter specialists, research institutions, Government and civil society organization and (c) bring out with a consensus document to be submitted to the Government of U.P. as part of advocacy efforts of IWP and IDI. The consensus building workshop was organized on 7th December 2010 at the National Research Centre for Agro forestry, Jhansi.

iv) Acknowledgements: IDI is thankful to IWP for fund this activity and engaging the Institute as a partner. We are thankful to the experts who contributed papers, all institutions and individuals we have had discussions, and the participants who actively participated in the workshop.

SECTION I

THE MAGNITUDE OF THE PROBLEM

1.1 Drought and Climate Change

Prolonged and recurrent drought, being experienced in India and various parts of south Asia, is one manifestation of climate change, partly caused by human interventions. Drought has been one of the primary reasons for widespread poverty and environmental degradation including deteriorating water quality and water security. The world has been more drought-prone during the past 25 years and the vulnerability of tropical countries to drought is likely to increase (Inter-governmental Panel on Climate Change, 2007). The South Asian region has been among the perennially drought-prone regions of the world. India, Pakistan and Sri Lanka, Bangladesh and Nepal have experienced droughts at least once in three years in the past five decades.

The effect of climate change has been noticed over the past several decades the world over in the common occurrence of flash floods, hurricanes, droughts, changing precipitation patterns, heat waves and other natural disasters. The land area classified as very dry has more than doubled since the 1970s. Many semi arid and arid areas are exposed to impacts of climate change and will suffer decrease of water availability. Increased precipitation intensity and variability will increase the risks of flooding and drought in many areas of India. Droughts, flash floods and other natural calamities are likely to worsen, disrupting the balance in the pattern of water supply and demand for water across agriculture, domestic and industry sectors. This will lead to reduction in the choice of cropping system and pose a threat to food security and increase frequency of water induced diseases.

High water temperatures, floods and droughts will affect water quality and exacerbate pollution from sediments, nutrients, dissolved organic carbon, pathogens, pesticides and salt and thermal pollution. This will negatively impact ecosystems, human health, water system reliability and operating costs. Rising sea levels will extend areas of salinisation of ground water and estuaries, leading to decrease in freshwater availability for humans and ecosystems in coastal areas. There will be further negative effects on hydropower, structural flood defences, drainage and irrigation systems and water management practices. A recent ADB report has warned that climate change will threaten Asia's food prices, energy security and population balance.

By 2055, climate is projected to warm the world by a dangerous 4 °C unless we stop pumping greenhouse gases into the atmosphere (UK Met Office) because temperature rises caused by greenhouse gas emissions will release ever increasing amounts of greenhouse gases. Warmer oceans may liberate more dissolved CO2, and plants may decay faster in a warmer climate. 17 different models launched by the British Met office concluded a 4 °C world by 2055, if emissions continue to rise. An average global increase of 4 °C translates to a rise of up to 15 °C at the North Pole. Sea levels would rise by up to 1.4 meters (Stefan Rahmstorf at the Potsdam Institute for Climate Impact Research, Germany). Even the less pessimistic estimate of a 0.65-metre rise by 2100 would put at least 190 million people a year at risk from floods (Jochen Hinkel).

There will be a mix of extremely wet monsoon seasons and extremely dry ones, making it hard for farmers to plan what to grow (Anders Leverman). Worse, the fine aerosol particles released into the atmosphere by burning fossil fuels could put a complete stop to the monsoon rains in northern India. Monsoons are generated by sharp heat gradients in the atmosphere where warm land meets and cools oceans. By blocking solar energy, aerosols cool the coastal atmosphere and sap monsoons' strength. In this alarming projections of the adverse impacts of climate change, it is important for U.P., the major food grain producing States of India to be prepared with an appropriate drought mitigation strategy.

1.2 Drought in Uttar Pradesh

Indo-Gangetic plains, in which the State of Uttar Pradesh is located, have very fertile crop lands with immense potential. The region abounds in ground water and irrigation is provided by canals, tube wells, rivers and other open water bodies. Although more than 80% of the crop lands are irrigated in the region, irrigation is not assured throughout the year. Dependence on rainfall for cultivation makes crop production vulnerable to frequent moisture deficits. Deficiency or excess of rainfall, hurricanes, tornados, hailstorms and other climate events, which have become more acute and frequent in the recent years in the context of global climate change, affect production and productivity of agricultural and allied sectors and threaten food security, employment and economic conditions of farmers, agricultural labourers and consumers. Once the drought has set in, relief measures are not sufficient to place the production systems and the economy of the people on an even keel.

Geographically Uttar Pradesh is divided in 71 districts. The state is divided in to 9 agro-climatic regions. Overall the climate of the state is sub-tropical with average annual rainfall of 770-1400 mm. Temperature during winters show a minimum of 1.5-5.7^{0}C and in summers the maximum of 38.4-47.8^{0}C. The nine regions are Terai, Western plains, West-central plains, South-western semi arid plains, Central plains, Bundelkhand, North-eastern plans, Eastern plains and Vindhyachal area. South-western arid plains, Bundelkhand and Vindhyachal are chronically droughtaffected areas while the central plains and eastern plains are prone to floods alternated by drought. One of the important causative factors for droughts, floods, hurricanes, tornados etc. is climate change.

During 2008-09 failure of monsoon threatened the projected growth rate of 6.1 percent of the Indian economy as 278 (44%) out of 820 districts were affected by drought. Of these, 58 were in Uttar Pradesh, the largest food grain producing State. Rains were 29 percent below average during the four month period beginning 1st June 2008. The latter is the monsoon period accounting for 80% of the rainfall. About 17 percent of India's domestic product comes from agriculture, which constitutes the livelihood of 65% of our people. The monsoon failure therefore will severely affect food security and growth rate is likely to fall.

There were droughts once in 16 years in 20th century. The frequency increased to 3 in 16 years from 1968-92. There were continuous 4 drought years from 2004-05 in some parts of Uttar Pradesh like Bundelkhand. There was rainfall deficit of 25% in 2004-5, 33% in 2005-06, 45% in 06-07 and 56% in 2007-08. Five of the seven districts in Bundelkhand had more than 50% rainfall deficit. Paradoxically, when there was drought in several parts of U.P in 2008-9, in Bundelkhand there was excess rainfall, causing excessive runoff and soil erosion from the barren hills into the swelled up seasonal streams and rivers.

1.3 Types of Drought

Drought is a weather related natural hazard, which is slow in onset and may evolve over months or even years and may affect vast regions, related to the timing of precipitation. It is a recurrent feature of the climate and occurs in virtually all climatic zones and its characteristics vary significantly among regions. It is related to a deficiency of precipitation over an extended period of time, usually for a season or more leading to water scarcity. Severity of drought is determined by other climatic factors such as high temperature, high wind, and low relative humidity.

There are four different types of drought, marked by their impacts. **Meteorological drought** is defined on the basis of the degree of dryness, in comparison to a normal or average amount, and the duration of the dry period. Definitions of meteorological drought must be region-specific, since the atmospheric conditions that result in deficiencies of precipitation are highly region-specific. **Agricultural drought** links various characteristics of meteorological drought to agricultural impacts, focusing on precipitation shortages, differences between actual and potential evapo-transpiration, soil-water deficits, reduced groundwater or reservoir levels, and so on. Plant water demand depends on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and the physical and biological properties of the soil. A good definition of agricultural drought should account for the susceptibility of crops during different stages of crop development. Deficient topsoil moisture at planting may hinder germination, leading to low plant populations per hectare and a reduction of yield. **Hydrological drought** refers to a persistently low discharge and/or volume of water in streams and reservoirs, lasting months or years. It is a natural phenomenon, but may be exacerbated by human activities. Hydrological droughts are usually related to meteorological droughts, and their recurrence interval varies accordingly. Changes in land use and land degradation can affect the magnitude and frequency of hydrological droughts. **Socioeconomic drought** relates to the effect of climate variability on the supply of economic goods, such as water, forage, food grains, fish, and hydroelectric power and occurs when the demand for an economic good exceeds the supply as a result of a weather-related shortfall in water supply.

1.4 Impacts of Drought

Drought impacts span many sectors of the economy and reaches well beyond the area experiencing physical drought as water is integral to society's ability to produce goods and provide services. Impacts of drought may be economic, environmental or social. Direct impacts include reduced crop, rangeland, and forest productivity, increased fire hazard, reduced water levels, increased livestock and wildlife mortality rates, and damage to wildlife and fish habitat. The consequences of these direct impacts illustrate indirect impacts. For example, a reduction in crop, rangeland, and forest productivity may result in reduced income for farmers and agribusiness, increased prices for food and timber, unemployment, reduced tax revenues because of reduced expenditures, foreclosures on bank loans to farmers and businesses, migration, and disaster relief programs.

The worst impact of drought is felt by people dependent on agriculture, who constitute more than 60% of the population. Relief oriented administrative disaster management response mechanisms are the usual responses backed by a few sector based initiatives and basic institutional mechanisms, but there are not many integrated approaches to reduce or pre-empt adverse impact of drought. As drought onset is gradual and generally considered to be transient, focus has been on policy responses, especially because drought is considered to be a transient disaster. There is an urgent need for drought monitoring, prediction, preparedness and mitigation. In many countries and regions, such as in Australia and the Mediterranean region, severe droughts have triggered water sector reforms in order to build great water security, managing water demand and safeguarding livelihoods. A common understanding of drought is essential for its highly comprehensive management in an integrated manner, addressing the overall development goals and well being of the people living in drought prone areas, by involving different sectors and stakeholders affecte**d.**

1.5 Traditional Cropping Systems as coping mechanisms against drought

The ability of people to cope with drought has been disturbed by the breakdown of the mechanisms which formed part of the traditional cropping system. These cropping systems were based on diverse drought resistant coarse cereals, mixed cropping, livestock rearing and agro forestry. Farmers had developed a well developed and time tested system of cultivating different varieties of drought resistant coarse cereals, dual purpose varieties of short duration grain and fodder, mixed cropping (eg alsi + mustard, lentil + mustard, groundnut + mustard, combination of maize with oilseeds or pulses etc), staggering sowing over time and so on. Use of organic manure, pesticides and green manure helped plants to grow well and friendly pest to thrive and enrich soil carbon. These management systems were able to withstand risks to a great extent though production was oriented towards subsistence and not for the market. Adoption of a cropping system based on modern input intensive technologies to address competitive market demands has altered the disaster cushioning mechanism of traditional agriculture. Dwarf varieties of pearl millet (bajra), sorghum (Jowar), high yielding varieties of soya bean chick peas (gram), pigeon peas, lentils, til and toriya have been adopted on a large scale, encouraged by an aggressive patronage of green revolution technologies, which enhanced production and productivity in the short run. Water guzzling varieties of sugar cane and mentha have gained popularity even in water scarce areas. These management systems required intensive irrigation, high doses of chemical fertilizers and pesticides and

heavy investment. But experience in Punjab and other agriculturally advanced areas showed that these technologies are not sustainable in the long run and a progressive decline of production and increase of land degradation problems have been reported in several areas. It is found that the input intensive agricultural systems are not resilient to Droughts and Pest Infestations, poison water bodies, degrade land (salinity, alkalinity, submergence) etc. deplete ground water table due to excessive pumping through tube wells and shallow tube wells and lead to several other associated problems.

1.6. Water Resources Development

The estimated annual volume of rainwater in U.P. is 23.54 million ha meter, of which about 17.05% gets evaporated, 29.5% is absorbed into the soil, 15. 5% is recharged as ground water and 37.5% flows into rivers as runoff. When there is inadequate precipitation, ground water is not recharged and availability from surface and underground resources get diminished, lowering the water table.

As per the U.P. State Water policy (1999) the state has total exploitable surface water of 161.7 billion cubic meters. Of this, 26.72% cannot be utilized at present.25.7 billon cu m is on;ly available for drinking, industrial and pollution control purposes from surface water resources. Any increase in consumption for non agricultural purpose would decrease agricultural use, adversely affecting production and productivity.

As per estimates, U.P has 3500 cu km of static ground water resources, of which dynamic fresh ground water available is only 80.82 billion cum. The volume of static ground water available is 29.43 billion cum for eastern region, 27.75 bcm for western region, 18.93 bcm for central region and only 4.72 bcm for Bundelkhand. Per draft area the average availability per ha for eastern and western regions is 34cm and 35 cm per ha respectively, whereas it is 41 cm for the central region and only 16 cm/ha for Bundelkhand.

However the volume of availability of ground water varies from year to year depending on the quantum of recharge from different resources and the precipitation. According to ground water experts, all ground water cannot be exploited, the critical range being 85-90%. Development of ground water in the state ranges from the lowest of 29% in Bundelkhand and 66% in Western region, the State average being 54%. Ground water recharge is to the extent of 84.2 bcm. The importance of ground water recharge for water security is evident from this.

Though a draft bill for regulating use of ground water has been prepared and is pending for a very long time, it has not yet been passed by the State Legislature. Looking at the critical importance of ground water, it would be necessary to give formal legislative sanction to the bill and enforce it strictly, looking at the rising and conflicting demand for water. In the year 2000 52.2% of ground water was utilized for irrigation and 0.82% for industrial and domestic use. About 75% of net irrigated land in U.P gets water from underground sources, indicating that irrigation through surface water sources has to cover a lot of ground.

Out of the total 133.13 lakh ha of irrigated area in U.P. 19.65% was irrigated through canals, and about 72% by tube wells, mostly private and 7.4% by open or blast wells. From this one can imagine the strain on ground water resources. Minor irrigation works mostly depend on ground water and in 2001-02, 1483.6 lakh ha irrigation potential was created in the state through state agencies and private individuals. The ultimate irrigation potential from ground water source is 167.9 lakh ha. However, presently the actual net irrigated area through minor irrigation at present is only 95 lakh ha. The water table in different parts of the state has depleted considerably, especially in districts with poor canal network. Canals are a good source of water recharge. 37 community development blocks of the state has been declared as over exploited, 13 as critical and 88 as semi critical. Regulation of ground water and appropriate measures for aquifer recharge are most critical in these blocks.

Irrigation and minor irrigation department handles the development of water resources in Uttar Pradesh. The major intervention that is now lacking is proper development of the conveyance system from water source to farmers' field and educating and motivating farmers in scientific and judicious use of water and water conserving technologies by strengthening water users' associations and other institutions. Only on farm water management and capacity building of farmers can improve irrigation efficiency , which is particularly crucial for drought management, increasing agricultural production and ensuring food security. The overall irrigation efficiency of the current irrigation system is only 55.19 %. It is very important to optimally increase irrigation efficiency through appropriate measures. It may also be remembered that the demand on water resources for domestic and industrial needs is also increasing and we have to take measures to conserve and recharge our ground water resources. As it is, in many areas there are issues regarding supply of potable drinking water both in rural and urban areas due to the problems of turbidity, alkalinity, salinity, lead and arsenic contamination, pesticide contamination etc adversely affecting health and nutrition of millions of people.

The Command area development programme consisted in irrigation management through water users' societies, adaptive trials and crop demonstrations, training and monitoring and evaluation. The programme however, suffered from the problems of large size, over administrative approach without peoples' participation, non linkages with the planning process at district, block and village levels, absence of operation and maintenance arrangements etc. Removal of these weaknesses will go a long way in improving irrigation efficiency and bring about agricultural prosperity in the command areas.

As already stated earlier, only 10% of runoff water is being utilized by storage structures through major, medium and minor irrigation projects and small storage structures. Therefore, rain water harvesting, using cultural and mechanical measures on watershed basis holds promise and must receive increased attention in the context of drought mitigation. Proper harvesting of rain water, besides recharging ground water, will make micro irrigation possible. Replenishing of aquifers will make water available for agricultural, industrial and domestic uses. Farmers' fields must serve as mini reservoir to store ground water and farmers must be educated to adopt this practice.

UP has 80% of agricultural land under irrigation through different sources. Out of this, around 30% area is irrigated by surface canal system. In this state, most of the major canal systems are through diversion of the river water, which included upper Ganga, lower Ganga, Ram Ganga, Sharda and Sharda Sahayak irrigation systems. In drought years the availability of canal water also gets reduced. The whole irrigation system needs to be categorized as:

- Assured irrigated areas
- Semi assured irrigated areas
- Partially irrigated areas and
- Areas irrigated only once in a year.

U.P. irrigation system was based on protective irrigation system which is now converted into productive irrigation system in which the crop water requirement for maximum production has to be met with. Naturally the area irrigated is much lower than the so called potential created. This needs thorough assessment and survey and through a detailed study each one of the irrigation systems must be grouped into the above categories. The department of agriculture should prepare a cropping plan based on the availability of water. The state is deficient in pulses and oil seeds. As such in areas where water availability is poor, promoting

pulses and oilseeds will be a suitable solution to meet the demand of the State. Traditionally Til (sesame) and Toria are the crops adopted by farmers in drought situations, but availability of seed particularly for sesame is very negligible and farmers have to depend on their own seed material.

1.7 Waste Lands

Wastelands are severely degraded lands which have gone out of cultivation and do not support even tree cover. Uttar Pradesh has the largest share of waste lands in India. In U.P., 2.269 million ha area had turned to wastelands and were not utilized for any cropping or other substantial green cover during the early 1990s. This covered about 9.4 percent geographical area of the State. The five important categories with nearly 1 percent or more of State's geographical area, include saline and alkali lands, lands with / without scrub, waterlogged / marshy land, gullied / ravinous land and degraded notified forest land. The other six categories having relatively less area are barren rocky area, degraded pasture, degraded land under plantation, mining / industrial waste and steep sloping area.

The three types of land degradation, which are prominent in the State, are:

(i) Soil erosion by water leading to the erosion of top soil and land deformation;

(ii) Salinization and alkalization of soil leading to land becoming unproductive; and

(iii) Water logging due to high water table conditions.

The problem of soil erosion and land deformation (gully and ravine formation) is acute in Bundelkhand and Gangetic plains regions. Salinization and alkalization are more pronounced in the Ganga plains, especially Ganga-Yamuna and Ganga-Ghaghra Doabs. The problem of water logging is slowly increasing in the canal command areas, specially the Central and Eastern plain districts of the State.

Soil erosion is prevalent in all the agro climatic zones. However, its severity leading to ravine development is more acute in south-western semi- arid, Bundelkhand and Vindhyan zones. In the Central Plains and Eastern Plains, river bank cutting leads to the development of *Diara or Khaddar*. Salinity / alkalinity are very common in Western Plain, South-western semi-arid Central Plain, Eastern Plain and a part of North eastern Plain zones. Water logging problem is associated with all the zones except Bundelkhand and Vindhyan zones.

The causes of land degradation in U.P are both natural and manmade. Among the natural causes hilly terrain and undulating topo graphy of Bundelkhand and Vindhyan regions have made them vulnerable to soil erosion, leading to gully and ravine development at several places due to the absence of protective vegetation cover. In the ravine tracts of alluvial plains, flooding during monsoon season leads to bank erosion, ravine development and water logging. Generally flat topography of the plain region also makes it vulnerable to watrelogging during monsoon. In the Ganga Yamuna doab, for example, the average slope of entire doab is only 0.03 % between Haridwar and Allahabad.

Intensive cultivation in the Gangetic plains, loss of vegetative cover due to increased cattle population, deforestation, extension of cultivation to marginal lands, and misuse of land are the causes for increased soil erosion and declining productivity. Canal seepage has also led to the rise of water table and water logging in several areas. The water loss through seepage is as high as 17 percent from the main canals and branches, 8 percent from distributaries and 20 percent from *guls* of field channels.

1.8 A Study of Drought in UP

A study on the effects of drought in 10 districts of Uttar Pradesh (excluding Bundelkhand) conducted by Agricultural Finance Corporation Ltd revealed the following:

i) The initial effect of drought was visible in the increase of fallow area from 10.3 percent of owned area in 2008 to 21 percent in 2009. This represents an increase of 10.7 percent over 2008. The highest percentage increase was in Varanasi (29%), followed by Rae Bareilly (20.9%), Allahabad (19.90%) and Moradabad (17.2%).

ii) Paddy occupied 48 percent of the cultivated area during Kharif 2009, followed by sugarcane (21%), and fodder crops (14%). While paddy was an important crop in all the sample districts, sugarcane dominated in Bijnor and pulses in Varanasi.

iii) At the aggregate level, area under pulses was only 6 percent and that under oilseeds and vegetables was very negligible at one percent each.

iv) Paddy was cultivated in 473.53 ha during Kharif 2009 by the sample farmers, which constituted 48 percent of the total area owned. Paddy was a major crop in all the sample districts. Both production and productivity were lower in Kharif 2009 than in Kharif 2008. Rice yield was expected to decrease from 25.38 q/ha in 2008 to 20.47 q/ha in 2009. This

represents a deficit of over19 percent of the yield level of 2008. All the districts would be experiencing shortfall, except Saharanpur, where more than 15 percent increase in yield level is expected. Here, however, it was observed during field interactions that farmers had shifted from cultivation of high value basmati rice to coarser varieties. So the yields of the two years are not comparable in respect to this district. The worst productivity decrease of nearly 37 percent occurred in Varanasi, followed by Moradabad (21.2%), Etawa (20.2%) and Bijnor (19.4%).

v) Though this study was not designed to understand the impacts of Customized Farmers' Training and related services, some positive trends are apparent particularly because those farmers who participated in CFT got higher yields, particularly in paddy, pulses and sugarcane.

vi) Oilseed production was also expected to reduce considerably. With regard to pulses, yield was expected to decline from 14 q/ha in 2008 to 11 q/ha in 2009. Decline of fodder production was also expected in the fodder producing blocks.

vii) Bijnor, Saharanpur and Basti together accounted for the bulk of sugarcane area and significant production decline was anticipated in these districts.

viii) The production decline occurred mainly due to wilting/stunted growth at early stages due to water stress, increase in weed growth and pest infestation (though the dry conditions were expected to slow down pest attacks).

ix) Access to credit and crop insurance facilities, the latter being an important risk cushioning mechanism, was very poor in most of the districts and even those farmers who were covered under crop insurance were not able to avail of compensation for crop loss. Crop insurance can definitely help in compensating the farmers from the effect of droughts and floods.

x) The study has shown that CFT farmers were more able to avail of crop loan and crop insurance schemes compared to non CFT farmers, probably due to the knowledge they gained through participation in training programmes and reading literature supplied during and after the trainings.

SECTION II

CONSENSUS BUILDING WORKSHOP ON DROUGHT MITIGATION MEASURES

2.1 Theme and Objectives of the Workshop

To deliberate on possible adaptation measures at policy level, the Institute for Development Initiatives (IDI), New Delhi planned to organize a workshop and come out with a consensus on Drought Mitigation Measures through Climate Adaptation Strategies for securing Agricultural Livelihoods for Uttar Pradesh. The India Water Partnership, New Delhi, a partner of the Global water Partnership, Stockholm, agreed to fund the venture. The consensus building workshop was organized on 7th December 2010 at the National Research Centre for Agro forestry, Jhansi, with the participation of scientists, professionals, NGOs and Government officials. Dr. J.C. Dagar, ADG (Agronomy and Agro forestry), ICAR was the guest of honour. The keynote address was delivered by Dr. S.K. Dhyani, Director, NRCAF, and Jhansi. Papers were presented on the topics of agriculture, livestock, forestry, water and social issues by invited experts. The papers were discussed and a set of recommendations emerged that could form the basis for a drought mitigation strategy that can be suitably adopted by the State Government for appropriate drought preparedness and mitigation strategy.

The workshop started with a brief introductory and welcome address by Dr. Joseph Viruthiyel, Honorary Director, Institute for Development Initiatives, New Delhi. He mentioned that looking at the plentiful rainfall during this year, it might look inappropriate to hold a drought workshop at this juncture, but still rains were slightly delayed this year also and some parts of the country reeled under drought like conditions. There were continuous drought months in the past few years. It was found appropriate to hold the workshop at Jhansi, the heartland of Bundelkhand, which is facing recurrent droughts due to its peculiar geographic features, distribution pattern of rainfall and denudation of vegetation on the hills. Covered with good tree canopy even till the 1940s, the vast hill ranges in the region are now denuded and are now left only with rock outcrops. These denuded hills emit extreme temperatures, forcing crops to dry up and animals and humans to suffer and drinking water become scarce. Though the region receives about 950 mm of annual rainfall, of which 850 mm falls during three monsoon moths, the rains are distributed in about 40 effective rainy days. On occasions the effective rainy hours are only 20 in a year, during which rainfall is

200 mm per hour in spells of about 15-30 minutes. Due to the denudation of hills, and the geographic formation, water cannot be absorbed into the ground and flash floods result in the numerous streams, which otherwise remain dry during the rest of the year. Drought, accompanied by flash floods, causes untold misery to the people. In this backdrop, there is a dire need to evolve a long term drought management strategy, whose elements are, prediction, monitoring, impact assessment and response. The other three economic regions also face drought like situations very frequently, with the additional problem of floods in the Ganga basin. The participants were requested to deliberate seriously on appropriate remedial measures for tackling the problem of droughts in the context of climate change.

2.2 Integrated Watershed Development

Dr. S.K. Dhyani, Director, NRCAF, in his key note address, dwelt on the need for integrated watershed management, particularly in the chronically drought prone areas of the State like Bundelkhand, drawing on the experiences of a model integrated watershed programme being pioneered by the NRC. Bundelkhand is among the most disadvantaged regions of the country owing to undulated and rugged topography, highly eroded and dissected land, poor soil fertility and scarce underground water resources. Most of the households derive their livelihood from agriculture which is mainly traditional and subsistence in nature. Crop failures are frequent due to low and erratic rainfall and lack of rain water harvesting techniques. In spite of having large number of streams and rivers (Betwa, Ken, Bagahin, Pahuj, Dhasan, Tons and Jamani) the depression of their channels and height of their banks render them for the most part unsuitable for the purposes of irrigation. Throughout most of the year the Bundelkhand region experiences acute scarcity of water for agricultural and domestic use. Water sources are varied and often seasonal, ranging from ponds, tanks, lakes and streams to open wells, bore wells and irrigation canals radiating out from large-scale dams. Most of the traditional systems such as reservoirs, primarily surface tanks and ponds; inundated irrigation systems; and *in-situ* storage facilities have been destroyed and are now almost non-existent. Most agriculture is single-crop rain fed with supplementary water from private open irrigation wells. Thus, large numbers of farmers are highly dependent on the monsoon rains to recharge these wells.

Conservation and management of rainwater holds the key for sustainable agriculture in this region. In the case of water resource management the focus is not merely on development of new water resource but also on efficient utilization of already developed

resource particularly based on indigenous system. This is to be attempted through substitution of high water requiring crops with low water requiring crops and also through adoption of efficient methods of irrigation (e.g. micro-irrigation system).

Dr Dhyani presented the findings of a case study of Garhkundar – Dabar watershed Tikarmgarh district in Madhya Pradesh part of Bundelkhand, where the National Research Centre for Agro forestry is implementing a model watershed development programme since 2005. Five major activities were undertaken i**n participatory mode**, viz., soil and water conservation measures, agro forestry system development, crop demonstrations with improved package of practices, plantation and human resource development. Soil and water conservation measures included construction of 150 gabions on first order drains, eight check dams in series on third and fourth order streams, *Khadins* (water spreaders) in depressions, and marginal bunding in 40 ha (3 km length) agricultural lands. Seventy on farm crop demonstrations for wheat, gram, sorghum, groundnut, black gram, green gram, sesame, pigeon pea, vegetables, etc, were conducted during 2006-07 to 2009-10 comprising improved agro-techniques including introduction of high yielding varieties. Farmers were persuaded to adopt agro forestry for higher income and productivity, risk proofing against drought and increasing permanent vegetal cover for restoring ecological balance, and as such, guava, Indian gooseberry (Aonla) and citrus based agro forestry systems were developed in 3 ha area on farmer's field. Nearly 6000 multi purpose tree species were planted along water course. Top working of Ber, lac cultivation, fish farming, incense making, etc. were introduced for income generation. Self help groups (SHG) were organized to take up joint venture for overall growth and development of rural economy. The study compared the results in the treated watershed to the situation in a control water shed.

The study showed the following positive effects:

- Check dams generated about 25 thousand cubic m water storage capacity in the watershed.
- Surface water availability in water courses and ground water availability in open shallow dug wells in 2009-10 increased to round the year in middle and lower reaches and for more than five months in upper reach as compared to four to five months earlier in lower reach only.
- The soil loss from treated watershed was 43% less as compared to untreated watershed in 2008.

- The N and P losses in treated watershed were 7.35 and 4.97 kg/ha, respectively while the corresponding losses in untreated watershed were 12.6 and 8.54 kg/ha.
- The productivity of major crops like wheat, gram, pea, mustard, sorghum and groundnut was increased by 1, 0.2, 0.4, 0.5, 0.45 and 0.32 Mg/ha, respectively in 2008-09 as compared to 2005-06.
- Cropping intensity increased to 150.2 % in 2009-10 from 69.3 in 2005-06.
- During 2005-06, the fodder requirement was higher as compared to availability and the watershed was fodder insecure by 0.569 Mg/year/animal which was met through import from outside watershed area. However, despite of tremendous increase in livestock population (34.4%), the fodder availability from all the sources increased and within four years, watershed became a fodder secure area with fodder surplus of 1.992 Mg/year/animal.
- Now enough employment opportunities are available within watershed and as such, the migration from the area reduced to 9% in 2009-10 from 29% in 2007-08.
- Therefore, integrated watershed management interventions are highly efficient in natural resource conservation and livelihood security. The technology developed and tested successfully here could be replicated in the entire Bundelkhand region particularly in red soils areas.

As a result of past experiences of Tejpura watershed and the Garhkundar watershed a new watershed has been selected in Jhansi district in which network approach is followed. Partners in the network are ICRISAT, Development Alternatives (NGO), NRCAF, and funding is provided by Ministry of Agriculture and Cooperation Government of India. The new watershed selected for network activity is comparatively better than the remote watershed of Tikamgarh. It is about 25 kms from Jhansi and has got better position in most of the parameters compared to the older one.

Considering the positive impact of soil and water conservation activity even in drought years in the treated watershed, a consensus emerged during discussions on the paper that to mitigate the effects of drought integrated watershed approach, i.e. ridge to valley approach should be followed through construction of low cost gabion structures from the stones available in the area and similar low cost treatments. It was also emphasized that the participation of beneficiaries is a key factor for the success of watershed activity.

The discussion veered to the failure of several check dams constructed in the past by state authorities. The discussion showed that structures failed due to:

- Improper design/overdesign in certain cases
- Wrong site selection
- Negligence in construction/poor quality of construction
- Lack of skill among the people involved in construction and designing

To increase the efficiency of structural measures and avoid the possibility of their failure, appropriate technical agencies must be involved in capacity building and monitoring of the constructions.

As a part of package for Bundelkhand region, state government has launched a large integrated watershed development programme in which latest guidelines for watershed development issued by National Rain fed Areas Authority of India will be the guiding factor for watershed development activities. In this project convergence from MNREGS with water shed development activity will be done. Convergence is the key to the success of integrated watershed development programmes and must be given top priority.

2.3 Chief Guest's Remarks

The Chief Guest, Dr. J.C. Dagar, ADG (Agronomy & Agro forestry), ICAR, drew attention to the gigantic task of drought management and the importance of this workshop, which should come out with consensus for concrete long term measures. Some parts of the country like Bihar, which were known for floods, faced drought this year when there was good rainfall in the rest of the country. Though how climate change is responsible for drought and floods is a controversial issue, we need to be prepared for all types of natural calamities, including drought and floods. There is not much difference in the total annual rainfall in the last 100 years, but what is changing is the distributional pattern of the rainfall through the year. Total temperature is on the rise, though some parts of the world are experiencing freezing temperatures. With the increase of irrigation, the problem of salinity is increasing. Water is central to drought management. We need to conserve every drop of rainwater through integrated watershed management. We must learn to use even waste water for crop cultivation. In Gujarat, through use of waste water for fodder cultivation, 30% of the fodder requirement in a drought year was met, preventing farmers from migrating with their cattle in search of fodder. We must learn to produce more food grains per unit of water. There is also

need for research focus on low water requiring crops, improving tree species, fruit tree based cropping systems and value addition.

2.4 Drought and Agriculture

2.4.1 **Correlation between drought and reduction in area under cultivation**

Dr. V. Ambekar, in his presentation, indicated the progress in agricultural sector particularly agricultural production at national level since independence. It rose from 51 million metric tonnes in 1950-51 to 230 million metric tons in the year 2008-09, which was one of the best years in the last many decades in terms of rainfall. In U.P. also the level of food grain production increased to 466 lac metric ton in the year 2008-09, against 117 lac metric tonnes in 50-51.

With respect to land use, net sown area in India remained constant around 140 million ha in the last 40 years, whereas in undivided UP it was between to 172 to 175 lac ha . In the present UP it is in the range of 164 to 168 lac ha. This fluctuation in net sown area in UP was corroborated with the rainfall received against the normal rainfall. In the years when rainfall received was lower than the average rainfall net sown area has come down along with the total production and productivity of food grains. This reduction in agricultural production adversely affects not only in lower agricultural GDP but also the overall GDP level of the country.

It was also pointed out that the state department of agriculture has developed a strategy for mitigation of different kinds of drought situation in which basis emphasis was on short duration varieties. However, though a number of varieties of crops for drought conditions are recommended the availability of seed appears to be negligible. It was emphasized that to ensure the supply of seed of alternate crops and short duration varieties a separate seed plan needs to be prepared to ensure sufficient quantity of seed to face drought situation. This requires production of breeder seed, foundation seed and certified seeds.

At the policy level there is a need for framing a definite policy for production of these seed crop and seed varieties with clear mandate that when drought situation does not arise and the seed remains unutilized, how the seed stock will be disposed off and who will bear the losses in the process must be clearly defined. It was suggested that the loss can be covered from relief funds provided to revenue department in such situations.

2.4.2 Indigenous Farming Systems to Mitigate the Effect of Drought

There are some indigenous farming technologies adopted by farmers to mitigate the effects of drought. For examples paddy and maize, jowar and pigeon pea , black gram and green gram are being sown as mixed crops. There is a need for assessing the traditional systems of mixed cropping, their strong and weak points may be examined and researchers may come out with better package of mixed cropping in which specific varieties of different crops can be recommended. It was also emphasized that the indigenous varieties in general have the capacity to face adverse weather conditions. Breeders may examine the quality of these indigenous seeds from the point of climate resilience. In their breeding programme they may like to have introduction of genes of these varieties into better strains to enable them to withstand the effects of drought and other forms of climate change.

2.4.3 Problem of Marketing and Food processing industry

It was pointed out that in the processing industry the data provided by Ministry of Agro processing shows that the share of farmers (cost of raw material) compared to the cost of marketing, processing and packaging, resulting in very high price of end product to the consumer. He gave the example of potato chips, packaged fruit juice and tomato sauce. There is a necessity to probe this issue and to ensure that farmer gets remunerative price for his produce and the consumer also gets processed material on reasonable price. In the whole process of agricultural marketing there are three stakeholders, namely, farmer, agri marketer/processor and consumer. There is a need to set up an agricultural regulatory authority (on the lines of telephone regulatory authority) to provide reasonable price for farmers' produce and also reasonable profit to processor/marketer and ultimately reasonable price to consumers. This is urgently required to ensure upliftment of farming community, whose share in population is around 65%.

It was pointed out that SHGs are formed in watershed development programmes as well as under SGSY and many other programmes. However the funding pattern and subsidy levels are different whereas all the programmes are under the banner of the Government of India. It appears that we should have similarity in financial support/subsidies to SHGS.

2.4.4 People's Participation

In watershed development activity, people's participation has been identified one of the major inputs necessary to make the programme successful. Keeping this in view, formation

of SHGs (for encouraging women's participation) and establishment of user groups has been given due emphasis in new guidelines for integrated watershed development provided by NRAA. It is generally observed that govt officials handling watershed programmes are not properly oriented for formation of these institutions. It is useful to involve good NGOs who can take up the activity of formation of SHGs/User groups through these groups peoples participation can be ensured. This must be a mandatory GO-NGO programme. Such a partnership programme was tried in UP Bhoomi Sudhar Nigam's sodic land activity which proved to be successful. It ensured peoples participation and transparency in programme implementation. Government machinery does have sufficient time or orientation to undertake rapport building and undertake other social mobilization activities. There must be clear understanding between the partners to achieve programme objectives.

2.5 Socioeconomic Impacts of Drought in Bundelkhand

2.5.1 Absence of integrated response to drought

Dr. Shailendra Pandey from Development Alternatives drew attention to the socio economic impacts of drought in the context of Bundelkhand and pointed out various issues that need timely intervention. Government and Development agencies carry out development work with minimal integration of disaster risk reduction strategy. The typical response against drought is that when it occurs, government waits until the levels reach a trigger point and sufferers started crying. Then it declares a package, and emergency and humanitarian agencies respond with life saving interventions. There is poor development structure to support drought relief measures.

2.5.2 Drought and pressure on ground water in Bundelkhand

Bundelkhand experienced **failure of monsoon consecutively** in the last 4-5 years. This led to reduction in natural recharge of groundwater. People then began to **use of ground water** even during Kharif. At the same time food security required i**ncrease in land under cultivation** and consequent demand for irrigation. **Availability of pumping technology** for groundwater withdrawal enabled farmers to tap water from deeper aquifers. **Inefficient water use practices** (e.g. flooding, field channels, seepage losses) in irrigation led to further depletion of water resources. There are hardly any government regulations regarding the use of groundwater. **Local irrigation water market** has developed, leading to increased

withdrawal (some farmers, who have the fortune of having water, are selling water to factories and road development works).

2.5.3 Drought Impacts in Bundelkhand

Drought had multiple impacts in the region. The social impacts are the following:

- Drudgery of women (in collecting fodder and firewood)
- School dropout and child labour
- Changes in marriage age of girls
- Neglect of the aged
- Reduced social visits and intra-family tensions
- Contract (bonded) labour
- **Conflicts over drinking water** collection
- Feeling of helplessness and depression-**low morale**
- **Reduction in food consumption** expenditure and nutritional status
  Mujhe Dilli ya Gurgaon ke road par sona achha nahi lagta. Par ghar parivar bhi to chalana hai. Budhi maa ko bhi dekhna hai. Kya karun?' **-** such expressions define the extent of distress migration in Bundelkhand.

The economic impacts revolve round the following:

- Drought led to crop failure, **loss of livelihoods** in agriculture, declining income levels
- **Food insecurity emerged as a serious problem due to** decline in production of food grains.
- **Fodder shortage resulted in** cattle death in large numbers and distress disposal to get cash.
- People became excessively dependent on drought relief. This led to increased **vulnerability.**
- Vlulnerability also increased due to indebtedness, sale of assets and jewelry
- *People have even sold agricultural land to purchase autoriskshaws, plying which they hope to earn more than by practicing agriculuture.*
- There is the case of a farmer in Rajapur owned 2 *bighas* of land (little over 1 acre) and had a well with plenty of water. (water available due to check Dam near the baruasagar nala constructed with the help of DA) He used to sell water to his neighbours to irrigate 33 *bigha* (13.20 acres).
- People have also started selling soil to brick kilns, increasing vulnerability.

Drought also had a number of environmental impacts

- Decline in natural recharge
- Declining water levels due to over-extraction;
- Water quality deterioration; increase in fluoride and salinity

- Loss of agro biodiversity
- Destruction of wild species biodiversity due to overgrazing and degeneration of forests
- Degradation of common pool resources such as *gauchars* and forests

2.5.4 Adaptation Strategies

Now the question is how people adapt to drought. One of the common responses is migration for livelihood. People have migrated to work on construction sites like the Commonwealth Games,Rail Network and hydropower work in (Delhi,HP &J&K), construction work in nearby areas (Real estate,NHAI etc), take up wage labour in market yards, stone quarries, drought relief sites,NREGA , or migrate for sharecropping in MALWA, Mahakaushal districts etc. (***Mujhe Dilli ya Gurgaon ke road par sona achha nahi lagta. Par ghar parivar bhi to chalana hai. Budhi maa ko bhi dekhna hai. Kya karun?'*** such expressions define the extent of distress migration in Bundelkhand).

The learning from the above experiences as observed in the field are the following:

- **Many of the coping strategies** to drought practiced by people are **not sustainable**.
- People who succeed in finding alternative occupations are less affected.
- Wells near check dams helped sustain some crop
- **Institutional support is helpful** to sustain livelihoods (dairy co-operatives, panchayat, NGO)
- Households with **diversified livelihoods are less affected by drought.**
- **Information networks** have been helpful to people to find labour elsewhere.
- Drought relief and drought proofing works helped the asset-less people to survive
- **Demand side management** of water helps sustain livelihoods
- **Improved agricultural practices** and drought resistant variety have potentials for food and livelihood security
- Livelihood finance strategies are needed
- Those who could not amend their social practices and cross social barriers were hit hard
- **"Landless asset-less" are not necessarily the ones worst affected**

The interventions required to manage the impacts of drought are the following:

- Provision of need based science and technology applications with a focus on fusion of local knowledge and organized knowledge for development of agriculture system and the livestock sector
- Provision of renewable energy (RE) services for household improvement and/or enterprise development
- Watershed based planning for managing Drought, water and livelihoods
- Strengthening different kind of institution (SHG,Farmers Club etc)

- As an important adaptation measure, there is a need to empower farmers with knowledge of water management techniques, drought resistant crops and varieties, conservation of ground water
- There is a need to customize the training packages further, keeping in view the above requirements, as drought will be a recurring feature due to the effects of climate change and global warming.

2.6 Challenges of Water Resources Management in South Asia

In his paper, Dr. **K.D. Sharma,** Technical Expert**,** *National Rainfed Area Authority, New Delhi*, discussed the water stress situation in South East Asia, which accounts for 21% of world's population but only 3.3% of the terrestrial area and 6.8% of the replenishable water resources of the world.

The region has some of the world's largest rivers that flow across state and provincial boundaries and across national borders, which convey very large river runoffs during the rainy season (causing floods) and very low flows during the rest of the year, and are frequently a source of conflict in the region. Although some arrangements presently exist to share the waters between the respective countries, their implementation has not always been satisfactory, and there is a widespread perception that these arrangements could be inadequate in times of increased water scarcity.

Despite the amount of precipitation it receives, the surface flows and dynamic ground water resources, Bangladesh, Bhutan and Nepal have acute shortages during the lean season flows; shortages are already felt in six river basins in India that are water stressed. Water scarcity is more widespread in Pakistan. Sri Lanka and Maldives, being islands, have a stand-alone hydrology.

One key challenge common to the entire region is low water availability in the lean flow season in most of the river systems leading to severe water-stress situation. Availability of water in coastal zones is particularly critical. There is/will be a larger gap between demand and supply at the consumer end. Looking at the total potential at the national level, Pakistan has a deficit, and India is on the brink of one, with large areas within the country showing stress. Bangladesh has shortages both under consumptive and non-consumptive uses, in March/April, even though the overall picture is one of excess availability on an annual basis.

Approaches to meeting the demand-supply gap are well defined but their implementation is beset with many problems – the basic one being of governance. There has to be a paradigm

shift in political thinking and attitudinal change in administering water. The approaches are categorised under four broad-level strategies envisaged to achieve sustainable development: governance and institutional reforms, increasing water use efficiency in all sectors, storage of runoff, and precipitation conservation. The demand-supply gap can be bridged by management options rather than by pursuing development options alone. It will be more challenging to bring about the necessary governance and institutional reforms that will enable technologies to be widely adopted. Further, the professional research on regional cooperation and intergovernmental conflict resolution along with social, political and economic expertise has the potential of making the most important inputs to the challenge of use of water resources for poverty alleviation and sustainable development in the region.

2.7 Drought Mitigation strategies for Uttar Pradesh particularly for feed, fodder, timber and firewood

In his presentation, Dr. P.S. Pathak, formerly Director IGFRI and currently, Coordinator, Centre for Application and Research in Ecotechnology, argued cogently that what we need is not drought relief, but relief against drought. It is a natural calamity that has become almost permanent. Water insecurity leads to economic insecurity and the only solution is to increase water supply by augmenting water resources. We need to maximize yield and minimize waste, avoid contamination. So far investment in the water sector has not been sustainable. In 1970 India had 2 Lakh problem villages in terms of drinking water supply. Even in Cherrapunji, which has 1000 – 4500 mm rain fall there is water stress in 9 months of the year.

2.7.1 Changes in Cattle population

In 2003, Western and Central regions of U.P had 21.2% each of cattle population of U.P,Eastern region had 45.4 percent and Bundelkhand had 12.2%. Eastern region also had the maximum concentration of sheep and goat population.

2.7.2 Low forest area

The percentage of forest area to geographical area was only 6.92% for the whole of U.P., - 4.42% in Western region, 4.92% in Central region,7.8% in Bundelkhand and 9.47% in Eastern region. Stems per ha of trees outside forests was lowest in Bundelkhat at 12, followed by 17 each in Western, Eastern regions and 19 in central region. Volume per ha was lower than the state average of 3.61.

2.7.3 Fodder Deficit

Percent of area under fodder production was lowest at 0.46% in Bundelkhand, compared to 8.12% in Western, 1.11% in eastern region and 1.9% in central region.

In terms of all the above resources, it is seen that Bundelkhand is at the bottom and the over all picture for UP is not very encouraging. For U.P. as a whole there was 36% deficit in green fodder 3.8 % in dry fodder and 45.3% in concentrates for the livestock.

2.7.4 Wood Deficit

Demand and supply of wood showed huge deficits for the whole of U.P. in the year 2000. There was a deficit of 96.7% for raw material for sawn wood, 88% for pulp wood and 94.3% for other industrial uses. The overall deficit was 93.3%. The demand for firewood is on the increase and is projected to increase to the level of 34.73 m/t in the year 2015.

Drought has significant adverse impact on fodder and feed resources: Failure of rain affects growth of grasses as well as water resources to livestock. The immediate impact is on the health of livestock, due to lack of feed, fodder and drinking water. This results in large scale migration of livestock, mainly cattle and sheep. A recent survey indicated production of poor quality fodder deficient in vitamin A, digestible carbohydrates and protein contents. There is also depression of feed consumption, milk production and reduction in conception rate**. There is distress sale of cattle during drought. Cattle is in fact one of the sources of cash needed to buy food grain during drought.**

There is a need to relook at our drought management strategy, with the following being some of the promising action points:

- Relooking and upgradation of our knowledge about mixed cropping, intercropping, catch cropping, mixed farming and multi-strata cropping concepts,
- Promotion of agroforestry, silvipasture, hortipasture and silvo-horti pasture systems etc, through large pilot scale demonstrations in the farmer's field in participatory mode
- 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.
- Combinations of Napier, *Cenchrus*, Guinea with Stylo for bund stabilization.

- Development of early maturing short duration area specific crop varieties including fodder crops, perennial grasses; bushes and trees.

The challenge of water stress can be met by considering water **as** trigger factor for sustenance of biosphere, its conservation, utilization, management, recycling and adopting integrated watershed management approach at micro-level.

For tackling fodder and feed scarcity the following steps need to be adopted:

- Prolonging the life of existing crops
- Use of failed crops as animal feed
- Increasing grass production on fallow lands, Govt. Farms
- Fodder production on banks of stagnated water ponds, rivers, canal banks, permanent/seasonal nalas with moist banks and empty tank beds
- Fodder production in sewage farms
- Tapping the forages from the reserved forests

To allow availability of quality fodder we need to enhance the perennial component of vegetation in drought prone areas. Improvement of natural pasture/grazing lands by reseeding, inclusion of leguminous components such as stylo, siratro etc. and introduction of top feed fodder trees and bushes such as ***Prosopis, Leucaena, Hardwickia,, Sesbania sesban, Moringa oleofera, Albizia, Zizyphus, Colopospermum*** **and** ***Azadirachta indica must also be attempted.***

Besides, there is a need to adopt agronomic practices like Soil – water conservation practices (Levelling, Bunding),Crop establishment techniques, Irrigation schedule & methods, Tillage, Mulching, adoption of appropriate cropping systems etc.

Another very important strategy is adoption of alternate land use systems. Alternate land use systems (ALUS) refers to perennial system/practice adopted to replace or modify the traditional land use. They aim at matching the land capability class, generating more assured income with minimum risk through efficient utilization of available resources. On arable land classes II and III we need to cultivate food crops through alley cropping agro-horticulture and intercropping with NFTs (Nitrogen Fixing Trees and Shrubs). For non arable land class IV and V, only fodder cultivation is possible through silipastoral, hortipastoral and ley farming (pasture management). For land classes VI and VII, tree farming and timber cum fibre farming are the appropriate practices.

In a 10 year rotation, annual production from silvipasture could go up to 14.6 t/ha, whose composition would be 45% forage from pasture,18% top feed, 15% lopped firewood, 9% harvested firewood and 13% timber, meeting the requirements of the rural households.

Another effective strategy would be enrichment of roughages

- Enrichment of low grade roughages with urea-The conventional roughages (like straws of maize, paddy, ragi etc.), available from the previous crops and stored, can be fed profitability with impregnation with 1% urea and molasses fortified with 0.5% of mineral mixture and 1% salt
- Urea-Molasses mix
- Urea Molasses mineral block
- Strategic supplementation

Processing forages for easy transport will be a very efficient adaptive strategy to tackle drought: This would include the following:

- Chaffing: Avoids wastage and prevents selective consumption
- Hay making: Harvesting and sun drying in swath for 3-4 days is cheapest method. Low moisture content of hay reduces costs and efforts involved in transportation and handling
- Bailing : Reduces volume of loose grasses to 2.5 times
- Densification: Densified fodders are 6-7 times less in volume and economical to transport to longer distances
- Cultivating forages on bunds has several advantages. Bunds around fields are a common feature on cultivated lands and occupy 2 to 10% of the cultivated area. Bunds are formed to demarcate field boundaries, conserve water and soil and to use as pathways. If not properly protected, the bunds are eroded by rains and damaged by animals.
- Wasteland rehabilitation success stories need to be replicated on large plots in drought prone areas.
- Upgradation of productivity potential and quality of non-conventional perennial vegetation of fodder value in drought prone areas through selection, breeding, stand management and agronomic practices.
- Identification and documentation of anti-quality factors in such plants

Creation of Fodder Banks in all drought prone areas using

- residues of crops like rice, pearl millet, finger millet, maize grown in irrigated areas

- harvesting and collection of perennial vegetation particularly grasses which grow during monsoon in drought prone areas and other areas of the country and
- leaf meal/whole plant meal of legumes like *stylo* and *leucaena* .

Livestock strategy

- Decreasing population of unproductive animals through castration/controlled breeding.
- Upgradation of indigenous livestock strictly following area specific animal breed concept. There is a need for state level breeding policy for livestock. Like Tharparkar which can graze under high temperature and produce more milk during hot summers.
- Creation of drinking water points in grazing areas.
- Identify livestock species/breeds having moderate body weight and resistance for prolonged dehydration.
- Establishment of permanent sites for cattle camps in drought prone areas.
- These cattle camps should be established in irrigated areas of the state
- Proper redressal of drought related animal health problems including precautionary vaccination.

A futuristic drought mitigation strategy will require re-orientation from cropping system based to farming system based on-farm participatory research, from annual arable cropping to perennial MPTS based research, shift from maximum production concept to optimum production and conservation of resource base, food-food cropping system to food-fodder-fuel concept targeted at sustenance of livestock related issues.

Any long term planning for drought management must be based upon strategies which take in to account livelihood opportunities and support system both in irrigated and rainfed portion of drought prone areas.

The issues related to talking 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 and (b) fixing short and long –term priorities focusing on overall improvement of environment of drought prone areas.

2.8 Specific action requirements in the context of Bundelkhand

Following the presentation by Dr. Joseph Viruthiyel, Director, Institute for Development Initiatives, on specific action points for Bundelkhand, the following consensus recommendations emerged:

i) Afforestation of denuded hills of the Vindhyan range

The Vindhyan hill range occupies considerable space but the vegetation of the hills disappeared. This has resulted in excessive temperature increase, increasing demand for water and making it difficult for plants and crops to grow. Afforestation of these ranges will help in retension of rain water, provide shelter belts to crops, animals and human beings, check soil erosion, preserve soil fertility, and minimize siltation of river beds. It will also prevent flash floods. So this is the area of primary concern. People's participation is a must to make the afforestation drive successful.

ii) Watershed management should also emphasize reviving of traditional dug-wells and tanks, desilting of ponds, command area development and efficient micro irrigation systems through adequate investment, particularly in Bundelkhand. Peshwa, Chandela or Bundela tanks, Haveli cultivation, dug wells and other traditional systems were neglected for a long time, partly due to public investments in surface and ground water resources and watershed management. These Common property or open access resources and other water bodies play an important role in generating income, employment and livelihood for the people.

vi) Renovation, repair, desilting, raising embankment and crest height to increase storage capacity of check dams, tanks, ponds, deepening and recharging through dug wells, cleaning of irrigation channels etc. can be taken up. These activities may be dovetailed with NREGS, BRGF, Artificial Ground Water Recharging and other such schemes.

vii) Digging trenches, constructing gully plugs, check dams, loose boulder check dams and gabions in non-arable land helps to improve biomass productivity. In-situ conservation of rain water by land shaping, contour/field bunding and many other practices consolidate the gains of interventions in the upper catchment. Cultivation of most suitable crops, high yielding varieties, cultural operation, application of fertilizers are important to optimize benefits of investments into watershed.

viii) There should be a strategy to improve flow of rivers and their secondary and tertiary tributaries through watershed management, constructing reservoirs and other surface

storage for irrigation, starting from the upper to lower landscape of catchment for full harnessing of rain during monsoon. This can be achieved through

- construction of farm ponds (especially in black soils they store rainwater for providing irrigation at critical stages and recharge ground water and revive dried up dug-wells);
- forest land treatment for in situ conservation of rains, restoration of eroded soil and retension of nutrients by digging staggered contour trenches on sloping land and loose boulder or gabion check dams in the nallas (streams).

ix) Joint Forest Management should have essential component of planting of fruit, fuel and fodder trees, shrubs, seeding of grasses or pasture legumes to improve forage, accompanied by transparent sharing of goods and services. Fodder trees like *Albizia* lebbeck, *A. procera, A. amara, Hardwickia binnata, Leucaena Leucocephala* (K8&S24), *Sesbania grandifolia / aegyptica, Ficus* sps. and *Acacia nilotica* should be included in the plantation. Grasses like *Cenchrus ciliaris*, Guinea grass and legumes like *Stylosanthes hamata, Clitoria ternatea* should be seeded on the soil excavated from trenches and in the barren spots. Expertise of IGFRI, Jhansi, National Research Centre for Agroforestry in Jhansi etc on seeds or sapling of fodder trees, grasses and forage legumes etc. can be utilized.

xi) In the JFM, sharing of forest produce with the participant community must be formalized right in the beginning to bring local inhabitants on board for sustainable management. This will ensure protection of forests catchment through incentivized social fencing by making local community as important stakeholders in regeneration process. The package should be implemented only through well designed JFMCs according to the New Common Guidelines on Watershed Development Projects brought out by National Rainfed Area Authority (NRAA).

xii) Treatment of degraded and scrub forest must be completed within 3-4 years.

xiii) Small ponds and bigger tanks for surface storage of rain water : The alluvial areas, pediments and valley plains of plateaus, which together occupy 70% of the area of Bundelkhand are suitable for surface storage through small ponds and some large sized tanks (not replacing the need for dugwells or artificial recharging of ground water). These should be provided in every village. Many of the Chandela and Bundela tanks, which have fallen in misuse due to official apathy and breakdown of the community management system, must be revived to provide water security to the

people of the region. The traditional water harvesting systems of the Eastern, Central and Western zones also must be revived.

xiv) Converting Bavdis and chohnras into masonry wells : Many of these traditional structures have become polluted or dried up a the step system provided therein permitted people to go down the wells. Converting them into masonry wells will enable their longer term use and maintenance.

xvi) Reviving Jalmandirs : These are traditional tanks built around temples. Preserving the tank was considered part of worship. It is necessary to revive these systems and involve devotee in their maintenance.

xvii) Contour bunding on sloping terrain

This can be taken up as a cooperative venture of neighbouring farmers.

xviii) Encouraging Water wheels, Masak and Mote systems and Persian wheels – the traditional irrigation systems : These energy efficient water lifting devices will go a long way in improving sustainable small scale irrigation.

xix) Shallow percolation tanks: These systems are efficient in enhancing percolation rate of rain water and recharge of ground water.

xx) Rain water harvesting: Roof top water harvesting is feasible in most areas of Bundelkhand. The water can be stored in a cemented basement tank. The second method is to construct dug wells with a parapet and cemented catchment area with multiple inlet points with steel meshes. These can be located within the village and on farmlands. A third method is to tap water from streamlets through dug up channels or through hose pipe.

xxi) Underground check dams: These check dams will prevent flow of underground water into river channels.

xxii) Artificial recharging: This can be done by pumping water from river courses into deep wells located some distance away from the river channel.

xxiii) Adoption of organic farming: This environment friendly, non chemical input based agricultural system will go a long way in restoring soil health as well as health of humans and animals.

xxiv) Regulatory mechanisms against mining and quarrying : Mining of granite, gneiss, sand- stone crushing, quarrying of river bed sand, cause a lot of environmental damage to the already fragile ecosystem of Bundelkhand. These activities need to be

restricted by law and enforced strictly to stop further damage. Stopping of waste water flowing into artesian wells also must be curbed.

xxv) Marketing and Value Addition : Intensification of diversification, marketing, value addition, processing and reducing risks are also essential to consolidate gains of enhancing productivity and other mitigative effects.

xxvi) Intensification of employment guarantee schemes, institutional credit including Kisan Credit Card Scheme and insurance system are important to mitigate vulnerability and strengthen coping mechanism.

xxvii) Reforming the public distribution system, which encouraged marketing of surplus production during normal or excessive rainfall years instead of storing for contingencies**.**

xxviii) Horticulture: Horticulture has scope to diversify income and mitigate risks associated with drought in rainfed areas. There are several potential markets like Jhansi for vegetables and fruits with good infrastructure like roads, railways and cooling and refrigeration facilities available under RGVVY. Seasonal migrant labour is available for nursery raising, planting and other operations.

Traditional fruits in rainfed area are ber, amla, karonda, custard apple, jackfruit, phalsa, bael, tamarind, citrus fruits (like orange, lemon, musambi etc). These crops are suitable for private and forest lands and can increase forest cover if 20% of species are planted with fruit trees. Plantation of fuel and fodder trees on field boundaries should be promoted under agro forestry. There is also scope for diversifying into improved varieties and cultivars/root stock

Traditional vegetables / spices / flowers are chilli, tomato, onion, brinjal, potato, marigold. Productivity enhancement possible by top working existing amla with bud wood of improved cultivars like NA-6, NA-7 and Chakiya; *in situ* grafting and top working of wild ber with bud wood of improved varieties like seb, umran and gola.

Cultivation of improved varieties of ber and amla, top working of wild custard apple with improved varieties like arka-sahan under NHM or NREGS can also be attempted. Cultivation of drought resistant pomegranate, improved varieties of bael, anjeer (fig), drought tolerant tomatos , Moringa olifera (Sahjan), Mahua, Coriander, Turmeric and Ginger , betel leaves etc can also be tried. Improved horticulture

requires setting up of nurseries, agro processing centres, rain water harvesting through reconfiguration or reshaping of land etc.

xxix **Wasteland Development :** Waste lands belong to Revenue department, Panchayats, community or private individuals. Self-Help Groups, User Groups, Cooperatives and Producer Companies of landless, small and marginal farmers can be organised for effective treatments to harness full benefits of investment to be made in upstream and downstream area. A long term lease of about 20 years to the community organisations registered under various acts would be essential. The programme may be linked up with ongoing schemes of IWDP, DPAP, and IWMP of Ministry of Rural Development, Governent of India, National Watershed Development Programme for Rainfed Areas, National Horticulture Mission, Bamboo Mission, NREGS and others.

Contour or field bunding, land shaping, constructing weirs in nallas (streams) to channelize flow, storing water for recharging or irrigation and retention of silt are important interventions on wasteland. Community based water harvesting, check dams or other structures can be planned for sharing irrigation for critical stages. Agro-forestry, horticulture, animal husbandry, rearing small ruminants, cultivation of improved varieties of pulses, oilseeds and cereals could be important components of the farming system. Fodder tree species as mentioned above can be considered for agroforestry model.

xxix) Private Lands Development

Common Guidelines for Watershed Development Projects elaborate institutional and organisational arrangements for integrated management of resources including micro-enterprises may be followed. These guidelines may be observed for ensuring capacity building, community organisation, people's participation, planning and implementation. Activities are supposed to be converged with NWDPRA, National Food Security Mission, Rashtriya Krishi Vikas Yojana, Horticulture Mission, Bamboo Mission, Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), Backward Region Grant Fund and other schemes.

Field bunding, land shaping, contour cultivation, gully plugs, farm ponds, recharging through dug wells, deepening of existing dug wells are important for conserving

rainwater. Cultivation of latest high yielding varieties of pulses, oilseeds and cereals tolerant to biotic and abiotic stresses elaborated in the chapter on Agriculture will improve productivity and income of the farmers. Enhanced production of crop residues like karvi, bhusa, non-grain part of pulses and oilseeds can be dovetailed to improve rearing of livestock to augment income and employment throughout the year. Details of improved varieties of cereals, pulses and oil seeds are given in Chapter on Agriculture for improving seed replacement rate, diversification and intensification.

Mulching, weeding, broad beds and furrows, ridge and furrow system of sowing especially in black, heavy clayey soils is useful both during excessive or deficit rainfall with productivity gain of 30-40%.

Sowing on raised beds or ridges avoids incidence of diseases in pigeon peas, chick peas, soybeans, maize, mustard etc. and promotes recharging of rainwater for subsequent crop cultivation. Custom hiring of specialized machinery would facilitate this new method of sowing to reduce risks of the cultivators.

SECTION III

CONSENSUS RECOMMENDATIONS

On the foregoing pages, drought management strategies have been elaborated. For the very vulnerable areas like Bundelkhand and the south western semi-arid regions, details given above need urgent attention. But, in general certain strategies for drought mitigation are as under:

3.1 Management of Water

Water conservation is the prime activity to mitigate the effect of drought. Judicious taking up of the following activities will provided security against drought.

- *In-situ* rainwater harvesting: bunding and terracing, vegetative contour barriers, land levelling, contour ditching, graded border strip, contour farming, cover crop and mulching, conservation tillage and deep ploughing, contour trenching.
- Rainwater/direct surface runoff harvesting: roof top collection / rain water cistern, dugout pond / storage tanks, diversion bunds / channels, water spreading
- Stream flow or runoff harvesting: nala bunding, gully control structure / check dams, weirs, water harvesting dams/stop dams, water diversions, percolation tanks/ponds
- Runoff inducements through surface treatment: metalled catchment, use of cover materials such as plastic sheet, bentonite, rubber etc, using chemicals for water proofing, water repellents etc.

- Equally important is the management of surface water. This includes the renovation and maintenance of surface water resources such as ponds, tanks, lakes, reservoirs and canals as also proper and judicious use of available water resources for irrigation and other purposes.

- Rreviving of traditional dug-wells and tanks, desilting of ponds, command area development and efficient micro irrigation systems through adequate investment, particularly in Bundelkhand. Peshwa, Chandela or Bundela tanks, Haveli cultivation, dug wells and other traditional systems were neglected for a long time, partly due to public investments in surface and ground water resources and watershed management. These Common property or open access resources and other water

bodies play an important role in generating income, employment and livelihood for the people.

- Renovation, repair, desilting, raising embankment and crest height to increase storage capacity of check dams, tanks, ponds, deepening and recharging through dug wells, cleaning of irrigation channels etc. These activities may be dovetailed with NREGS, BRGF, Artificial Ground Water Recharging and other such schemes.
- There should be a strategy to improve flow of rivers and their secondary and tertiary tributaries through watershed management, constructing reservoirs and other surface storage for irrigation, starting from the upper to lower landscape of catchment for full harnessing of rain during monsoon.

3.2 ***Management of Canal Irrigation***

Efficiency of irrigation is low at about 60% due to losses upto 20% in main canal and up to 8% in distributories and minors. Suggested measures to increase efficiency are the following:

- Replacing leaking head and cross regulators with more efficient control systems;
- Regulatory enforcement of frequent and unchecked cross bunds and obstructions in canal beds;
- Ensure consistency in supply of irrigation water in ower reaches of branch and canal distributories and minors;
- Stop unauthorized irrigation'
- Ensure equity in distribution of irrigation water so that tail end farmers receive adequate quantity of water through effectively functioning W.U.As.
- Remove losses at field channels
- Repair and desilt canal system before every crop season
- Provide adequate electricity for lift canal system/provide other energy efficient water lifting systems
- Replace equipments that have outlived their span
- Line main canal to check seepage loss.
- To minimize losses from canal to irrigation field, which is to the extent of 49% at present, farmers must be educated to adopt improved irrigation practices such as border method, check basin method, ridge and furrow method and ring method according to the crop and water availability. Transfer of knowledge on how, when

and how much to irrigate will go a long way in enhancing irrigation efficiency and increase productivity.

3.3 Ground Water Management

Management of Ground water is the third major imperative. This includes the management of water resources such as state tubewells (efficiency 25.4%) private tubewells (efficiency 59.1%) etc. Low efficiency is due to:

- Uncertain power supply, forcing farmers to use diesel and push up cost of pumping; energization of tubewells are resisted by power distribution companies due to non profitability and non payment of dues by consumers;
- Incomplete and poor water distribution channel systems particularly for state tubewells;
- Non replacement of outlived equipments;
- Poor maintenance
- Non construction of field channels

Removal of the above deficiencies and educating farmers in judicious use of water, coupled with the adoption of measures suggested for aquifer recharge, will go a long way in increasing the efficiency of ground water use, which is very crucial for drought management.

3.4 ***Need for farming system Based Planning***

Our drought management strategy needs a relook on some of the promising action points:

- Need based application of science and technology focusing on fusion of local and organized knowledge for development of agriculture system with the livestock sector. Knowledge upgradation on mixed cropping, intercropping, catch cropping, mixed farming and multi-strata cropping concepts with working models for application,
- Provision of renewable energy (RE) services for household improvement and/or enterprise development
- Watershed based planning for managing Drought, water and livelihoods
- Strengthening different kinds of institutions (SHG,Farmers Club etc)
- As an important adaptation measure, there is a need to empower farmers with knowledge of water management techniques, drought resistant crops and varieties, conservation of ground water.
- There is a need to customize the training packages further, keeping in view the above requirements, as drought will be a recurring feature due to the effects of climate change and global warming.

- On marginal lands promotion of agroforestry, silvopasture, hortipasture and silvo-horti pasture systems etc, through large pilot scale demonstrations in the farmer's field in participatory mode.
- Conservation agriculture practices such as zero tillage, bed-furrow irrigation, direct seeded rice, fertilization, adjusting spacing, soil and water conservation through mulching, use of anti-transpirants/Jal shakti etc. need popularization.
- Combinations of Napier, *Cenchrus*, Guinea with Stylo for bund stabilization and forage production.
- Development of early maturing short duration area specific crop varieties including fodder crops, perennial grasses; bushes and trees.

3.5 ***Livestock Management***

The overall strategic elements for livestock management for drought conditions are the following:

- Promote quality livestock rearing and management that can become economic to the people. Introduce milk marketing and processing systems that can reduce the exploitation of the producers.
- Allocate need based cultivated area for year round fodder crop production.
- Develop degraded lands, marginal lands for fodder development through silvipastoral system.
- The area under ravines, canal banks and road sides need to be developed through agroforestry where fodder and fuel wood trees are integrated. This will address the resource conservation needs also.
- Integration of perennial grasses like Hy. Napier and Guinea grass in the cropping system for higher quality production of fodder.

When Drought has already set-in

- In order to prolong life of the existing crops arranging some life saving irrigation or using the failed crop as animal feed.
- Producing fodder on the bank of stagnated water in ponds, rivers, canal banks, empty tank beds.

- Use of waste water like sewage farms for fodder to mitigate fodder crisis.
- Collecting forages from the reserved forest areas.
- Enriching low grade roughages of the previous crops with impregnation of 1% urea and molasses fortified with 0.5% mineral mixture and 1% salt.
- Provision of fodder banks in the areas vulnerable to drought.