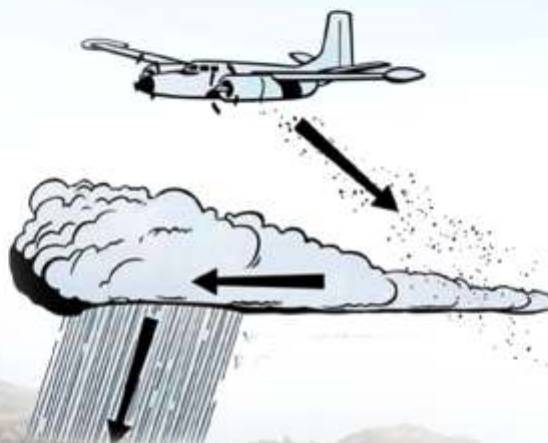


National Conference on “DROUGHT MANAGEMENT STRATEGIES”

COMPENDIUM OF
BEST PRACTICES ADOPTED
IN DROUGHT MANAGEMENT



Organised by



Government of
Karnataka

Co-ordinated by



Karnataka State Natural
Disaster Monitoring Centre
Bengaluru

8-9th March, 2018
Bengaluru



National Conference
on
“DROUGHT MANAGEMENT STRATEGIES”
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**Karnataka State Natural Disaster Monitoring Centre,
Bengaluru**

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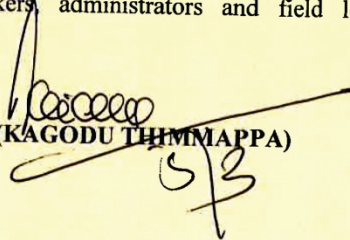
Foreword

Drought differs from other natural hazards since it has a slow onset, evolves over months or even years, affects a large spatial extent but causes little structural (infrastructure) damage. The onset and end and severity are often difficult to gauge. Condition of drought appears primarily, though not solely, on account of substantial rainfall deviation from the normal and/or the skewed nature of the spatial/temporal distribution to a degree that inflicts an adverse impact across the sectors.

Change in land use pattern, excessive deforestation, increased urbanization, industrialization and greenhouse gases emission are causing climatic imbalance/climate change, the manifestation of these are clearly visible in terms of increased frequency and intensity of droughts in the past decade.

Though natural disasters such as drought are beyond one's control, we can definitely reduce the adverse impacts of drought by enhancing our capability to reduce risks and losses through holistic response system, developing coping mechanism and resilience of the community.

I take this opportunity to extend deep appreciation to Revenue Department (DM), KSNDMC and all States who have contributed in bringing out the Compendium on Drought Management Strategies. The best practices documented in the compendium will be lessons of great inspiration to all concerned to come up with innovative ideas to tackle and contain many of the maladies associated with droughts. I am sure that this compendium will be ready reckoner on drought management to policy makers, administrators and field level functionaries.


(KAGODU THIMMAPPA)

ಕೃಷ್ಣ ಬೈರೆಗೌಡ

Krishna Byre Gowda



ಕೃಷಿ ಸಚಿವರು ಹಾಗೂ
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Minister for Agriculture &
In charge - Bengaluru Rural District
Date: 05.03.2018.

PREFACE

The Drought, a creeping and recurring natural hazard has plagued society across the globe throughout the history. It is a period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance. It affects natural habitats, ecosystems, and Socio-Economic structure of the society. All sectors, from agriculture to modern complex industries, will all be affected.

The changing climatic condition across the World, is expected to increase the intensity and frequency of the disasters like Drought, especially in tropical countries like India. Consequently, the economic burden on the Governments will increase manifold and it will be a humongous task for the Governments and other stakeholders to mitigate the socio-economic impact of drought on the community. Though Drought has been a recurrent phenomenon, we are yet to evolve an holistic drought management strategy to tackle all-encompassing adverse impact of drought. Drought management requires new planning and adoption of strategies which will enable the governments and the stakeholders to effectively mitigate the impact of drought in future.

As Karnataka is severely and successively affected by Drought, Govt. of Karnataka has taken several innovative initiatives to effectively Monitor, Mitigate and Manage Drought condition in the state. Drought monitoring mechanism developed by KSNDMC in the Karnataka is first of its kind in India. Similarly, The programs like KrishiBhagya, Creating Farm Ponds, Promoting Millets farming etc by the Agriculture Department, crediting input subsidy to the farmers Bank Accounts through DBT by using indigenously developed "PARIHARA" application, implementing and managing Crop Insurance Scheme through "SAMRAKSHANE" application, are few examples of drought mitigation and response measures conceived and implemented in Karnataka which are worth emulating.

The National Conference on "Drought Management Strategies – Best Practices Adopted" organized by Govt. of Karnataka, on 8-9 March, 2018 at Bengaluru is a timely effort to pool in best practices adopted in the Country and take stock of scientific advances in Drought Management Strategies in order to effectively mitigate adverse impact of drought. This Compendium of "Drought Management Strategies – Best Practices Adopted" comprises several practices adopted by different Departments in several states and other National & International Agencies in the country. Taking these Innovative and Appropriate strategies to the farmers and motivate them to adopt these methods must be the next action to be taken up by all of us.

I appreciate the efforts by the organizers, especially Dr G S Srinivasa Reddy, Director, KSNDMC and his Team in bringing out this collection of Best Practices which will be a Hand-Book for all the stakeholders in the field of Drought Management in the country and abroad.


(KRISHNA BYREGOWDA)

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National Conference
on
“DROUGHT MANAGEMENT STRATEGIES”

8-9th March, 2018

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1.1. An ICT enabled Drought Monitoring System in Karnataka

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1. Introduction

Drought is a creeping and recurring natural hazard that has plagued society across the globe throughout the history. It affects natural habitats, ecosystems, and many economic and social sectors, from agriculture urban water supply modern complex industries. The wide variety of sectors affected by drought, its diverse geographical and temporal distribution, and the demand placed on water supply by human-use systems make it difficult to develop a common definition of drought. However, in simple terms, it is defined as “a period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance” (Richard, 2002).

Depending on the severity and recurrence of the Drought, the economic burden on the Government increases in short and long term. It will be a humongous task for the government and other stakeholders to ease the socio-economic impact of drought on the community. Identifying the drought vulnerable areas in advance, periodically assessing the drought situation by using Science & Technology based indicators, planning and implementing mitigation measures by involving all the stakeholders is the effective way of Drought management.

2. Drought Vulnerability of Karnataka

Karnataka, one of the India's eighth largest state in terms of geographical area (19.1M. sq.km) is home to 6.11 crore people (2011 Census) accounting for 5.05% of India's population. It has the net cultivated area (2010-11) of 10.5 M Ha, net irrigated area of 3.49 M Ha and net rainfed area of 7.01M Ha. Due to both spatial and temporal variation in rain fall, the disasters like droughts and floods occur simultaneously in the different regions of the state. Droughts are more common than the other disasters in the state thus affecting rain-fed Agriculture production system. In the last 16 years about 13 years one

or the other districts of Karnataka has experienced severe drought. Some of the Taluks have been subjected to drought condition for more than 5 years consecutively.

Looking to the gravity of drought situations in the state, a multi-pronged /multi component approach study was undertaken to assess the Drought vulnerability at taluk level. Under this study four major components and twenty eight sub-components/indicators that are relevant to drought were considered over a period and analysed to develop the composite index of Drought Vulnerability. The major components of the study deals with the Climate (CI), Climate – Crop cover (CCI), soils (CSI) and livelihood aspects (LI).

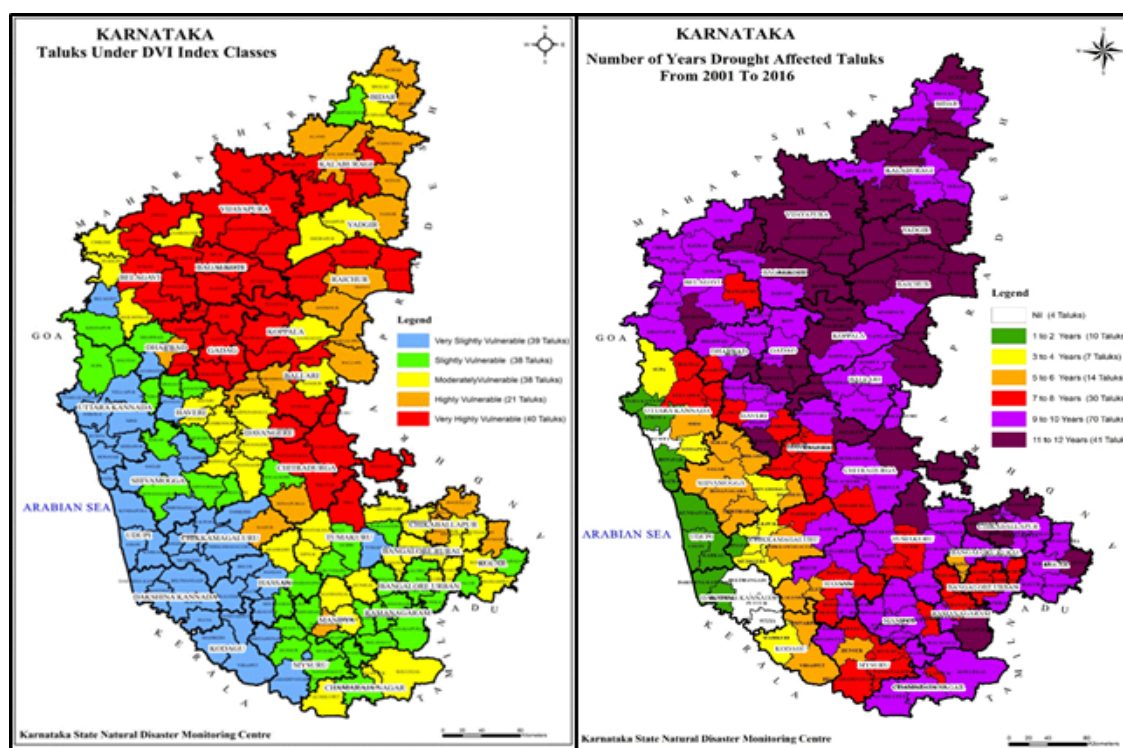


Fig:1: Map depicting the Composite Drought Vulnerable Index (DVI) of Karnataka

The composite index developed based on four indices mentioned above indicate that about 65 Taluks are highly and very highly vulnerable, 34 Taluks are moderately vulnerable, about 38 Taluks are slightly vulnerable and 39 Taluks are very slightly vulnerable.

About 38% of house holdings are in the taluks of high and very high drought vulnerability. Of the different groups of population about 41% of total population, 97%

constitute minority and under-privileged (SC & ST) population, 41% of total workers and 53% of agricultural workers are in taluks of high and very high vulnerability.

Resilience index which indicates the capacity of the people to recover from the effect of drought reveals that about 72 taluks are highly resilient, 17 taluks are very highly resilient, while 49 taluks are moderately resilient and 38 taluks are low and very low resilient.

The overlay of drought vulnerability classes over the Agro-climatic zones indicate that Northern dry zone (81%), North-eastern dry zone (65%) and Central dry zone (49%) have extensive areas of very high drought vulnerability, North-eastern transition zone (62%), North-eastern dry zone (35%) have much area under of high drought vulnerability in the state. In general, the dry zones (2, 3, 4, 5, 6) and transition zone(1) have extensive areas of moderate, high to very high drought vulnerability, while hilly and coastal zones (9 & 10) have extensive areas (68&100%) of very slight drought vulnerability.

3. Monitoring and assessing Drought Indicators in Karnataka

Some numerical standard is needed for comparing measures of drought from region to region, as well as for comparing past drought events. Because of the complexity of drought, no single index has been able to adequately capture the intensity and severity of drought and its potential impacts on such a diverse group of users. However, with an objective of facilitating the decision to declare drought over a specified administrative unit and provide relief assistance to the drought affected people in time, Ministry of Agriculture, Cooperation and Farmers welfare, Govt. of India has brought out a Manual for Drought Management which comprises Scientific Indices for Drought assessment. It is acknowledged that a combination of carefully chosen indicators and indices derived from ground level and satellite observations is capable of identifying areas with drought.

The Ministry of Agriculture & Farmers Welfare, Govt. of India, has brought out a Manual for Drought Management in 2009 and a revised manual for Drought Management has been brought out in December, 2016. The manual prescribes several Science & Technology based Indices, as mentioned below, to be used by respective states to assess the Drought condition.

3.1 Rainfall Related Drought Indicators

a. Rainfall Deficiency:

In Karnataka the rainfall data collected from TRGs at every Grampanchayath at every 15 minutes is being used to calculate the rainfall deficiency at Hobli / Taluk level across the state on daily / weekly / Monthly basis.

b. Dry Spell:

The seamless rainfall data obtained from the TRGs network established in the state is being computed against the Normal rainfall to determine the extent of Dry Spell at hobli level on weekly basis. It is also used to determine the break-monsoon condition and temporal and spatial distribution of rainfall in the state.

Both Rainfall deficiency and extent of Dry spell parameters has been used to assess the occurrence, intensity and spread of Drought condition at hobli / Taluk level in the state.

c. Standard Precipitation Index (SPI)

In Karnataka the historical rainfall data upto Taluk level, available for more than last 100 years (since 1902), and present day rainfall data is being used to determine the Standard Precipitation Index by calculating the rainfall departure with respect to rainfall probability distribution function and the index used as a Drought indicator.

As the SPI is to be calculated only on monthly basis, it is a limitation to assess the Drought situation on weekly basis. Thus in Karnataka, Rainfall Deficiency and Dry Spell Indicators are being used to assess the Drought on weekly basis. However, at the end of the month / season the SPI is used to corroborate the Drought condition indicated by other parameters.

3.2 Remote Sensing based Vegetation Indices

Satellite based crop condition indices like Normalized Difference Vegetation Index (NDVI), Normalized Difference Wetness Index (NDWI) and Vegetation Condition Index (VCI), which point towards agricultural drought are being used to assess the Drought Condition in the state.

Though the data obtained through many satellites is available, we have been using MODIS TERRA Satellite data is used to derive the above mentioned vegetation Indices, as the data is available at open source for more than last 15 years. However, considering the changes in the cropping pattern in the state, the MODIS data for the last 10 years is being used for Drought assessment at Daily / Weekly / Monthly / Seasonal basis.

3.3 Soil Moisture Based Indices

Available soil moisture is also an indicator of drought, especially in rainfed regions. It is suggested that one of the two soil moisture based indices viz., (a) Percent Available Soil Moisture (PASM), or (b) Moisture Adequacy Index (MAI) is used in conjunction with other indicators to determine drought.

Crop water requirement is the amount of water needed by various crops to grow optimally. Crop water requirement mainly depends on the climate, duration of the growth stages and crop factors. The database of observed weather parameters available at Karnataka State Natural Disaster Monitoring Centre (KSNDMC) on daily basis, Potential evapotranspiration (PET) and Actual Evapotranspiration (AET), Moisture Availability Index (MAI) is being worked out using the following formula: $MAI = (AET/PET) * 100$

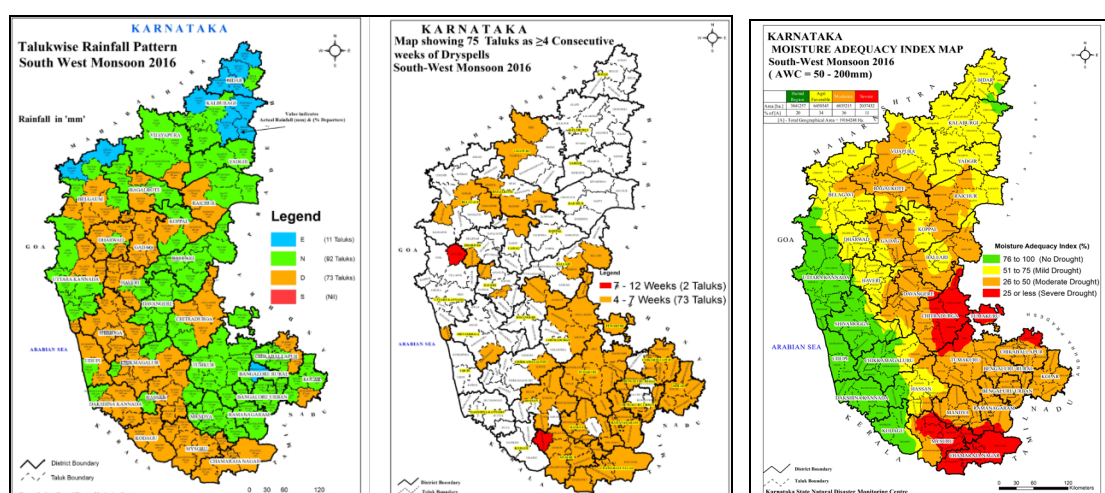


Fig:2: Map depicting the Rainfall deficiency, Dry Spell and Moisture Adequacy Index in Karnataka during Kharif 2016

3.4 Agriculture Indicators

The extent of sowing is an important indicator of the spread and severity of drought. The area under sowing provides reliable information on the availability of water for

agricultural operations. If the area under crops sowing falls to 50% of the normal by the end of July / August then it is considered as Drought of a 'severe' nature. In case of Rabi, crop sowing less than 50% of the normal sown area during October-November is a strong indicator of Drought development.

The crop sowing data collected by the field officers of Department of Agriculture, GoK at Taluk level is being used to assess the sowing status on weekly basis in the state and used as an indicator to assess Drought condition.

A mobile App is being developed and used on ICT based Gadgets by the field officers of the Dept. of Agriculture, GoK to collect survey number-wise Crop information on the crop status along with their photographs across the state on weekly basis.

After the notification and declaration of Drought, ground truth data of crop damage is being assessed using ICT based application gadgets by the field officers of the Dept. of Agriculture, GoK. Each data set along with photographs to depict the crop damage are geo-tagged and the data is made available with the Memorandum submitted to Govt. of India.

3.5 Hydrological Indices

Depletion in stream-flow, reduction in reservoir storages / water spread area and the rate of ground water table depletion can serve as useful indicators of hydrological drought.

The reservoir storage and inflow data collected on daily basis, by the Department of Water Resources for all the major reservoirs in the state are being used to derive Reservoir Storage Index and Stream Flow Index on weekly basis and used as hydrological Drought Indicators. Similarly, minor irrigation tank storage data is also being used to assess the hydrological drought condition in the state.

Ground water level data, collected by the Ground Water Directorate, GoK and CGWB on monthly basis, is used to assess the fluctuation in Ground water level and derive Ground Water Drought Index on monthly basis.

The Drought Indices derived as mentioned above are being used to assess the agricultural and hydrological Drought in the state.

4. Scientific, Administrative and Governance structure of Drought Monitoring and Early warning system in Karnataka

Karnataka state has the distinction of being the first state in the country to establish a Drought Monitoring Cell (DMC) in 1988. Subsequently, the DMC was renamed as Karnataka State Natural Disaster Monitoring Centre (KSNDMC) and function as an Autonomous body affiliated to Department of revenue (Disaster Management), Govt of Karnataka. KSNDMC has developed a robust mechanism to monitor and assess Drought periodically at Hobli level which is helping the response players to take necessary action in time to mitigate the impact of Drought in the state.

Karnataka, has established a dense network of Solar Powered and GPRS enabled Telemetric Rain Gages (TRG) stations covering all the 6000 Gram Panchayaths (25 sq. km each) and Telemetric Weather Stations (TWS) at all the 747 Hoblis in the state (200 sq. km each). The other key features of the entire network are, Rainfall measuring accuracy is 0.5 mm, Data is collected at every 15 minutes with no Manual intervention, all the stations work 24 x 7 and 365 days. The dense network of rainfall and weather monitoring stations is first of its kind in the country.

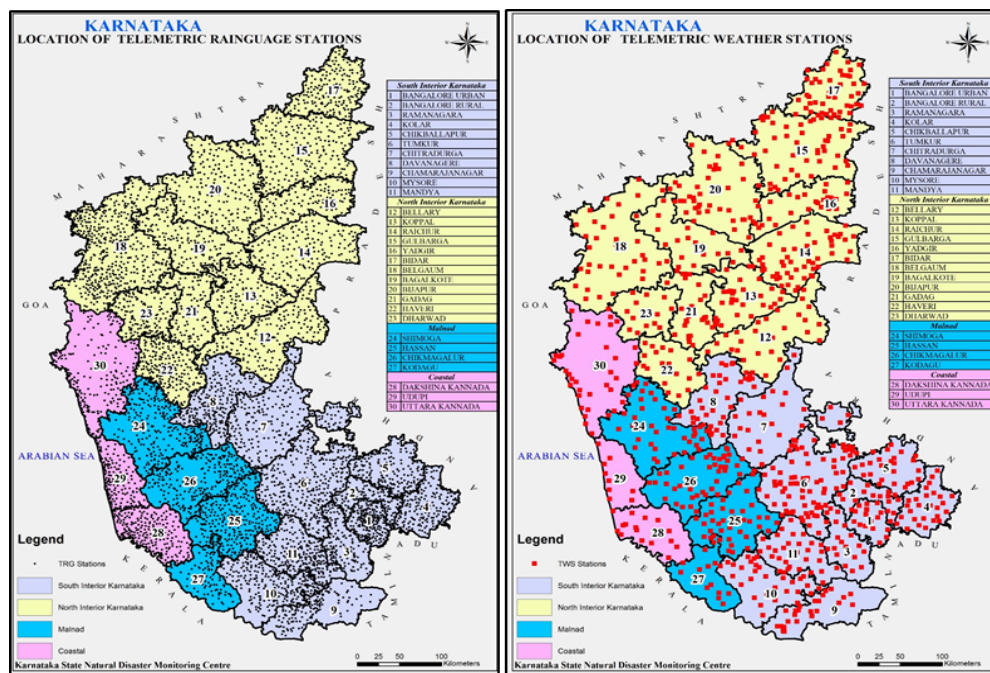


Fig.3: Map depicting the network of TRG and TWS Stations in Karnataka

The near-real time data collected through the network of stations is being used for monitoring and assessing Drought indicators at Hobli level in the state on weekly basis.

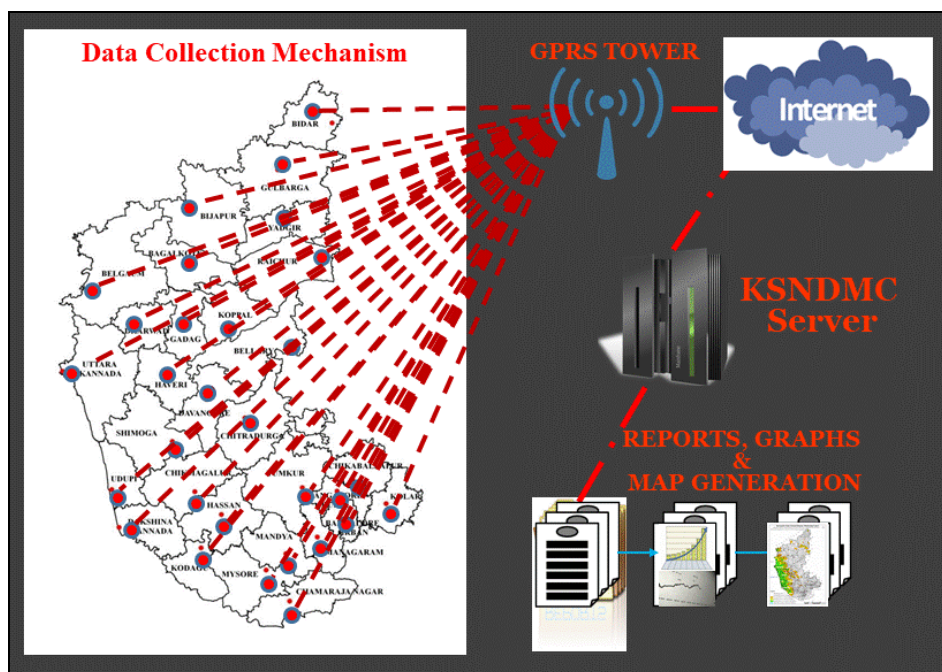


Fig.4: Weather data collection mechanism operational in Karnataka

In collaboration with Space Applications Centre (SAC), Ahmedabad, an Indian Space Research Organization (ISRO), Govt. of India, Karnataka has been generating Grampanchayath level weather forecast for the state. On daily basis the forecast comprising parameters like Rainfall, Cloudiness, Temperature, Humidity and Wind Speed & Direction are being generated at 12 hours format for next three days.

Similarly, Grampanchayath level rainfall forecast at 24 hours format for the next ten days (medium range) is also made available in collaboration with Satish Dhawan Space Centre (SDSC-SHAR), Sriharikota, another organization of ISRO, Govt of India.

The observational 15 minutes data for weather parameters collected through weather monitoring stations installed in Karnataka are being ingested into the model for improving the weather model output.

Apart from short and medium range forecast, long range weather outlook generated by the India Meteorological Organization (IMD), Govt. India is also being made available to the end-users through one platform.

High Spatial and Temporal resolution scientific data on various parameters collected from the ground level enables the Policy Makers and the Govt Executives at all levels to take appropriate decisions at any stage without any delay.

The prevailing drought condition and the weather forecast at Hobli / Taluk level is reviewed on weekly basis by the department of Agriculture, GoK through Video Conference with all the Taluk and District officials of the department. Subsequently, the results of the drought assessment based on the science and technology based indices are being made available to all the line departments to plan and implement mitigation measures in their respective domain as well as collectively.

By considering the Drought assessment report and the weather forecast, the Weekly Weather Watch Committee headed by the Additional Chief Secretary (ACS) and Development Commissioner and the Principal Secretary / Secretary to Govt. of all the line departments of GoK as members, reviews the drought condition and guides the implementation of mitigation measures by concerned line departments.

The Cabinet sub-Committee on Drought headed by the Revenue Minister and having Cabinet ministers of Agriculture, Horticulture, Animal Husbandry, Rural development, Water Resources and Food & Civil Supplies and Law as members of the committee, periodically reviews the Drought condition and guide the implementation of mitigation measures. The policy decisions are also taken up by this committee as and when required to facilitate the implementation of programs or schemes to mitigate Drought impact.

The drought condition assessment results are being reported through weekly Video conference to the Ministry of Agriculture and Farmers Welfare, GoI.

The Science & Technology based Drought condition assessment results at Hobli level / Taluk level on daily / weekly basis are being used by the Govt. of Karnataka to identify and notify the areas affected by Drought and rollout mitigation measures in time. The data is also used to prepare and submit memorandum to seek financial assistance under NDRF from Govt. of India for managing the Drought.

After the declaration of Drought, the NDRF / SDRF funds released by the Govt of India is being transferred as Input Subsidy through Direct Benefit Transfer (DBT) to the farmers Bank Accounts which are Adhar seeded. A computer application named “PARIHAR” has been developed and utilized by the Dept of Revenue (DM), GoK for this purpose.

5. Information Dissemination to the stakeholders

It is common experience that required precise information about the natural disasters like drought is not available, on real/near real time, to the community and response players. It takes long time to obtain the data and lot more time to integrate and generate information/reports/advisories. Therefore, providing timely precise information to the end user will be a key for mitigating impact of Drought. If the information is provided well in advance, it will help to ease the situation further.

A robust early warning system comprises of installation of field monitoring sensors – for weather, geological, hydrological parameters; collection of data at real / near-real time, transmission of the data to a central computational/analysis center; data processing; analysis; alert recognition; simulation through appropriate mathematical models, customized report generation; dissemination of the alerts/reports/advisories to the users. The system developed and operationalized in Karnataka by KSNDMC has addressed all the above mentioned issues and has been providing solutions to the end users.

Information, reports, weather related forecast and advisories are being made available through mobile phones, e-mail and web portal to DC's, CEO's, HQA's, AC's, Tahsildars, JD's (Agri), AD's (Agri), Agri Officers, Raitha Samparka Kendras (RSK), Farmer Facilitators under Bhoochethana Program, Krishi Vigyana Kendras (KVKs) and Agriculture Universities.

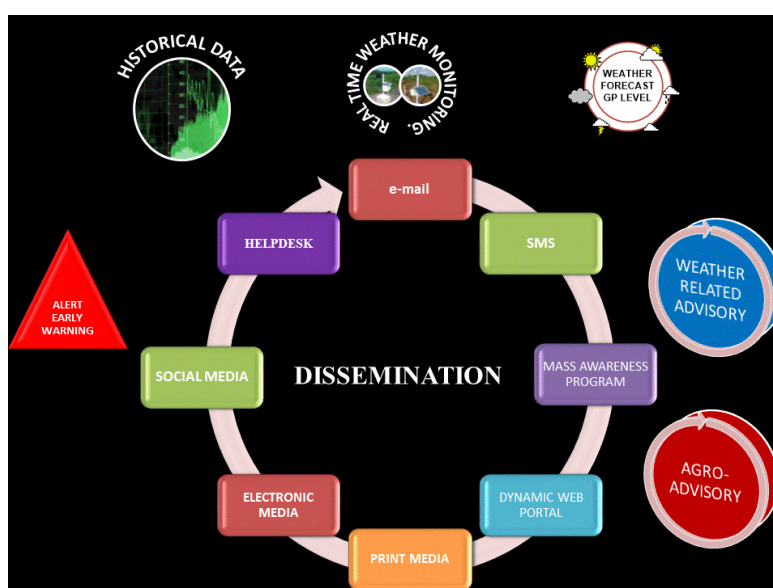


Fig.5: ICT based information dissemination mechanism operational in Karnataka

As the information and advisories are reaching the executives on near or real time basis, it is helping them immensely for planning and executing mitigating measures, mobilizing and organising the resources for tackling any eventualities, executing rescue operations etc.

The near-real time weather data is also being made available to the stake-holders through a dynamic Dash Board on GIS enabled web-portal www.ksndmc.org where in data collected from the weather / rainfall monitoring stations at every 15 minutes is uploaded. Apart from station-wise data, distribution maps are also generated dynamically on the dashboard.

5.1 Community Help-Desk VARUNA MITRA

In order to disseminate the weather related information, forecast and advisories to the general public, KSNDMC has setup an interactive help-desk “VARUNA MITRA” with a dedicated Telephone line (9243345433) which is functioning 24x7x365 basis. The general public, especially the farmers are calling “VARUNA MITRA” and collecting necessary information for their respective Grmpanchayath.

As a result day by day the number of calls to “VARUNA MITRA” has been increasing substantially.



Fig.6: 24x7 Help-Desk VARUNA MITRA

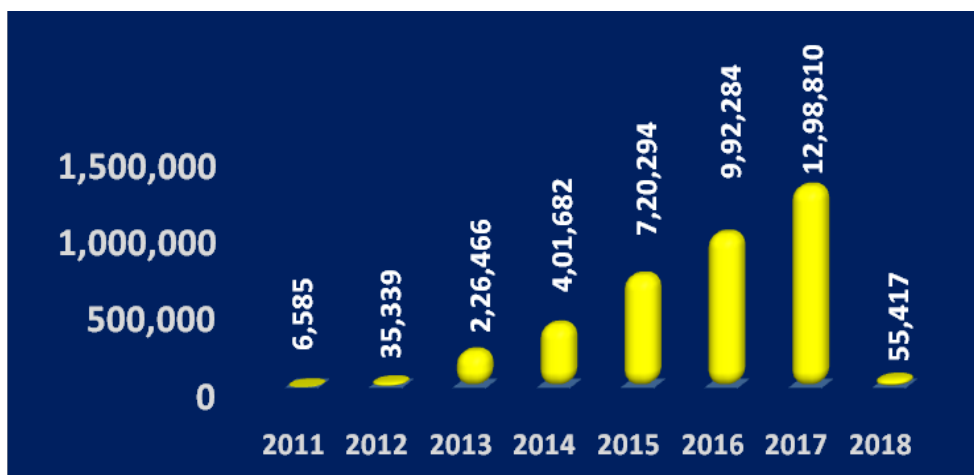


Fig.7: Annual Call details of 24x7 Help-Desk VARUNA MITRA

The services and information provided through “VARUNA MITRA” has been helping the farmers either to minimise the Crop loss due to weather aberrations and / or increase the yield and the related profit because of timely intervention in their agricultural activities. It has been helping them at all stages of their agricultural activities like, ploughing, sowing, inter-crop cultivation, spraying pesticides, adding fertiliser and more importantly identifying right time for harvesting.

Institute for Social and Economic Change, Bangalore conducted a study to evaluate the effect of “VARUNA MITRA” services on the community. The result of the study shows that conducted by, showed that

- “VARUNA MITRA” has been functioning as a bridge between scientific organisation and the end-user. As the information is provided through simple terms in regional language it has been very convincing and effective across the community.
- Every individual farmer collecting the information from “VARUNA MITRA” is in turn disseminate it to 15-20 people in his area, thereby these services have been reaching lakhs of farmers every day.
- More than 80 % of the farmers are satisfied with the resolution, time and accuracy of the *Grampanchayath* level weather related information and advisories provided through “VARUNA MITRA”

The Grampanchayath level customized weather related Information, forecast and Agro-Meteorological advisories are being disseminated in regional language to about 28 lakh farmers through SMS to their mobile phones directly.

6. Conclusion.

Planning and implementing drought monitoring and mitigation mechanism is the need of the hour to ease the impact of Drought. Karnataka State through KSNDMC has taken a proactive measure and has built a mechanism with a multi-disciplinary approach to provide Science and Technology based solutions to tackle the situation created by Drought in Karnataka. State-of –the-art techniques employed by KSNDMC have been of great help for the policy makers and Government Executives to plan and execute mitigation measures to manage drought at micro-level. As the farming community is directly involved in the process, availability of right information at right time has been of immense help for them to minimize the loss due to drought condition.

2.1 Best Practices adopted under Krishi Bhagya Scheme

Department of Agriculture

Seshadri Road, Government of Karnataka

INTRODUCTION

Karnataka is predominantly an agrarian state wherein nearly 68% of the cultivated area is under rain fed farming. The scope for increasing the irrigation potential in the state is limited in view of its geographical position as an upper riparian state. A close analysis of rainfall pattern of the state indicates that 3 to 4 years in every decade face severe drought at, sometimes consecutively. A vast majority of dry land area receive an annual average rainfall of 450 to 700 mm, which is highly erratic and unevenly distributed in cropping seasons. Reduced rainy days and increased rainfall intensity as a resultant of climate change has added undesirable dimension to the sustainability of rain fed ecosystem in the state.

Krishi Bhagya, Karnataka Government's flagship programme is a step forward to help farmers by making dry land farming not only sustainable but also lucrative by harvesting surplus water and using it as a lifesaving resource. Presently the program is implemented in all the 30 districts of Karnataka. The program which is still under implementation has resulted in construction of 1.93 lakh farm ponds benefitting the critical irrigation needs of 4.13 lakh hectares of area through conservation of excess runoff water and utilizing the same during the critical stages of crop production as a life saving irrigation. The program has also supported to establish 2460 poly house/Shade net structures in which high value flowers / vegetable crops that fetch higher income have been cultivated.

INITIAL SITUATION AND CONTEXT OF THE SCHEME

The districts were characterized by predominance of poverty, erratic rainfall, frequent droughts, distressed migration due to unemployment, malnutrition, lower crop yields due to degradation of agriculture land, higher proportion of Scheduled Caste (SC), Scheduled Tribe (ST) and other vulnerable sections of population.

OBJECTIVE OF THE SCHEME

The Krishi Bhagya program was started keeping in view the chronic problems of drought faced by farmers' of rain fed agriculture. This program was introduced with major objectives:

1. To improve the rain fed agriculture scenario with the efficient management of rainwater, to enhance farm productivity.
2. To introduce advance techniques by way of using advanced farm machinery and equipment
3. To contribute to ecology and environment by conserving rainwater, minimizing soil degradation and promoting climate smart and remunerative agriculture.
4. To reduce distress migration by creating employment opportunities locally and to improve the livelihoods of the vulnerable sections of the population.

SCOPE AND IMPLEMENTATION ACTIVITIES

The major activities of the program includes construction of farm ponds, providing polythene lining to farm ponds to avoid percolation losses, promoting in-situ moisture conservation structures like field bunds, providing micro irrigation systems along with diesel/solar pump sets ,efficient use of harvested water in the farm pond, demonstration of high value cropping systems to increase the farmers income, support animal husbandry activities to generate off-farm subsidiary income to farmers family and provide shade net and poly houses to farmers to promote high value crops.

1. **Farm Pond:** Farm pond is a water harvesting structure to harvest runoff water constructed with various dimensions (10*10*3mtr, 12*12*3mtr, 15*15*3mtr, 18*18*3mtr and 21*21*3 mtr) based on the catchment area for providing protective irrigation to the crops during critical stages of the crop growth. Program support is upto 80% of the investment to the general category and 90% to SC / ST category of farmers. So far 1.93 lakhs farm ponds are constructed in farmer's fields.
2. **Polythene lining to farm ponds:** In order to avoid percolation losses and to store water in the pond for longer duration, farm ponds are fitted with 300 micron HDPE

polythene lining. In addition, provision is also made for alternate lining methods such as Brick Border,/Kadapa/Slab /soil/Cement lining. For this farmers are assisted upto 80% of the cost. So far 76,320 farm ponds are fitted with polythene lining.

3. **Bunding activities:** In order to promote in-situ moisture conservation, Bunding activities are encouraged in the program. Various types of Bunding activities includes compartment bunding, Tied ridges, conservation furrow, Graded bund, Zing Terrace, Contour bund, Field bunds, trench cum field bunds. Farmers are provided financial assistance up to a maximum ceiling of 2 hectares per farmer for this bunding activity . So far 58,575 farmers in the state have been benefitted from bunding under this scheme.
4. **Diesel pump sets:** To lift water from farm ponds and to provide protective irrigation through micro irrigation, diesel pump sets are provided to the farmers. Financial assistance is provided up to 50% to general and 90% to SC/ST categories of farmers for the purchase of pump sets. So far 65,915 diesel pump sets are distributed to farmers free of cost. This will enhance crop productivity and income of farmers.
5. **Micro Irrigation units (Drip/Sprinkler):** Farmers are assisted with drip or sprinkler irrigation in order to save and provide optimum and uniform water application to crops during the critical stages of crop production. Farmers are provided financial assistance up to 90% to all categories of farmers, for installation of micro irrigation systems limiting to 2 hectare area per farmer. So far 87,867 farmers have installed and successfully irrigating the crops with micro irrigation systems.
6. **Farm Demonstrations:** In order to motivate the farmers and fellow farmers to adopt innovative technology in terms of latest varieties, farm machinery and equipments, farm demonstrations were taken up under the scheme with a cost of Rs.5000 per hectare.
7. **Animal Husbandry activities:** Animal husbandry, agriculture and allied activities have been the core livelihood for majority of the rural people since time immemorial. It provides productive employment, especially self employment and the most valuable supplementary income to a vast majority of rural households, who are small and marginal farmers and landless laborers. Livestock provides increased

economic stability to the poor masses. They act as cash buffer in case of small stock and as captive reserve in case of larger stock. Financial assistance up to 50% has been given for rearing of cross bred cow, improved buffalo breed, sheep, goat, piggery and backyard poultry.

8. **Shade net around Farm pond:** In order to avoid evaporation losses of water and accidental deaths in the farm ponds, shade nets around farm ponds are provided as a safety measures with a financial assistance up to 50% of the cost.
9. **Construction of Polyhouse / Shade net:** Poly house farming is a new technique in agriculture in the state to grow high value floriculture and vegetable crops which fetch higher income. It is considered as an important milestone in improving the economic status of poor dry land farmers and reducing the dependency on rainfall and optimum utilization of the resources. This has enabled farmers to grow high value vegetables and flower crops, thus fetching higher income. Farmers are provided financial assistance up to 50% of the investment to the general category and 90% to SC/ST category of farmers with a ceiling limit of 1 acre. So far 2460 farmers have availed this benefit under the scheme.
10. **From 2015-16** a Special package program is being implemented in 7 districts of the state (Kolar, Chickballapura, Ramnagar, Tumkur, Bidar, Hassan and Kalburgi) covering 23 taluks, where there was continuous dry spell during last 4 years. Under Special Package, in addition to all the above components, assistance was provided to Sericulture crops, Sericulture rearing house's and Bore well recharge component. This program is being implemented with grants from the krishi bhagya scheme .
11. **During 2017-18**, assistance is provided for the Construction of farm pond, laying of polythene sheets, distribution of Diesel pump sets, installation of micro irrigations units, shade nets around the farm ponds and recharge of bore well components

INNOVATION

The Krishi bhagya scheme is built in with many innovations to the farmers which not only help to safe guard ecology and environment in protecting and optimum utilization of natural resources but also helping the farmers to harness higher yield and

income to improve their livelihoods. A package of different components were considered in designing and formulating the scheme by state agriculture universities and Engineering wing of agriculture department, Horticulture, Animal Husbandry, Sericulture, Watershed department.

Farm ponds are constructed with different dimensions like (10*10*3mtr, 12*12*3mtr, 15*15*3mtr, 18*18*3mtr and 21*21*3 mtr) based on the catchment area for providing protective irrigation to the crops during critical stages of the crop growth. This is an innovative approach as it not only considers the technical feasibility in terms of catchment area but also the requirement of the farmer based on the type of soil, crops grown etc. These farm ponds are important measures to harvest excess run off and prevent soil degradation.

Laying polythene lining to farm pond is the latest innovation to prevent percolation losses and to store the water for longer time to provide critical irrigation to standing crops as and when required.

As farm ponds are constructed in dry lands, hardly there is any power supply or pumping facility to lift the water, realizing this; farmers are provided with diesel pump sets to lift the water. This pump set is cheap, simple to handle and highly economical.

Water is a precious resource and every drop of water harvested must be put to optimum use. To address this, micro irrigation is another technological innovation introduced in the scheme to optimize the water use efficiency and minimizing the wastage of water. Another important innovation to minimize wastage of water and pest and diseases is construction of shade net around the farm pond and construction of poly houses. These poly houses have proved to be economical and effective in minimizing the cost of production and maximizing the returns to the farmers.

Yet another innovation in the scheme is integration of different farming systems such as floriculture, agriculture, dairying, fisheries etc in order to increase the on-farm and off-farm income to the poor and marginal farmers of rural Karnataka

IMPLEMENTATION AND COSTS

The Krishi bhagya scheme a flagship program of Karnataka Government is being implemented in all the districts of the state. The program initially started in 5 agro-climatic zones during 2014-15 and now it is extended to all the districts of the state spread across all 10 agro-climatic zones of Karnataka. The scheme has so far invested Rs 1920.82 crores for construction of various structures such as farm ponds, poly houses etc. The activities in the scheme are being implemented by the ultimate beneficiaries with the technical assistance from the department of Agriculture. For each of the activity the beneficiary pays his contribution ranging from 10-20% depending on the type of activity and vulnerable category to which the beneficiary belongs. The beneficiary level contribution is mainly insisted in the scheme in order to inculcate a sense of ownership and to ensure sustainability of the created infrastructure.

The program implementation though initiated in 23 districts of the state during 2014-15 covering 107 taluks and further during the year 2015-16, the scheme was extended to 131 taluks of 25 districts where the average annual rainfall was less than 850 mm. During 2016-17 another taluk was added making the total 132 taluks across 25 districts. During 2017-18, owing to the demand from the farming community, the scheme is extended to all the districts of the state excluding command areas.

To bring awareness to farming community, trainings and seminars were conducted at village level. Further, field days showcasing the benefits of the scheme were organized in the farmers own field who have successfully implemented and harnessed the results. In each district, model farm ponds were constructed in Krishi Vignana Kendras run by State Agricultural Universities for the purpose of demonstration and to bring about awareness among the farming community. Wide publicity regarding the scheme was given in awareness programs such as Krishi Abhiyan scheme of the agriculture department and in Krishi Melas organized by State Agricultural Universities.

During 2016-17, farmers meet was organized in Koppal district to commemorate the success of the scheme. Around 30,000 farmers from all over the state participated. During the meet there was exchange of information, successful farmers narrated their success stories to other farmers , which helped to motivate non-beneficiary farmers.

DESCRIPTION OF ACHIEVED RESULTS

The scheme has resulted in construction of 1.93 lakh farm ponds, polythene lining to 76,320 farm ponds, field bunding in 58575 farms, Diesel pump sets to 65915 farm ponds, adoption of sprinkler irrigation system by 87,867 farmers and construction of 2460 poly houses with shade net for growing high value commercial crops.

- The implementation of the scheme ,as per the evaluation studies conducted by state agricultural universities, there is an increase in average yield by 50% in agricultural crops and there is increase in average yield of horticultural crops cultivated in poly houses to the extent of 80%.
- Annual Income of krishi bhagya beneficiaries was found to be almost doubled (Beneficiary farmer-1.26 lakhs, non-beneficiary farmer-0.625 lakh per annum)
- The scheme has helped vulnerable landless people in generating employment and thus preventing the migration of youths from the rural area.
- The scheme has motivated farmers to grow high value commercial crops with conserved rainwater using shade net poly house.
- The scheme has resulted in preventing substantial soil degradation, runoff and recharging the ground water table and increasing the vegetation.

REPLICATION POTENTIAL

Replication within the State

Krishi bhagya scheme was implemented as a pilot scheme in 5 agro climatic zones of Karnataka State. After receiving immense demand for the scheme from other parts of the state and looking at the impacts, the scheme was extended to all the 10 agro-climatic zones across all 30 districts of the state in a phased manner. Hence, the program is best replicated within the state as result of better performance and realization of scheme objectives.

Replication by other states within the country

Looking at the successful implementation and huge demand generated from the public, many neighboring states such as Andhra Pradesh, Telangana, Tamil Nadu, Kerala

etc have visited the state to study and replicate the model in their states. Government of India has also sought details of the scheme and planning to replicate it in other states.

Replication outside the country

The Krish Bhagya scheme not only attracted the attention people and policy makers within the state or within the country but also drawn the attention of people outside the country. Students from American University, Washington visited Krishi bhagya scheme in July, 2017(26th and 27th) and August, 2017 (1st and 2nd) under the leadership of Dr. Mary Breder, IISEC, Bangalore. The participants opined the scheme is a boon to farmers especially dry land farmers who can realize better yield and expressed that the scheme is worth replicating

Publications

THE HINDU
‘Krishi Bhagya has become a model for the country’



Union government has sought details of the scheme: Minister

The Krishi Bhagya scheme, introduced by the government to help farmers by making dry land farming not only sustainable but also lucrative, has become a model for the country, Krishna Byre Gowda, Minister for Agriculture, has said.

Mr. Byre Gowda, accompanied by Basavaraj Rayaraddi, Minister for Higher Education and district in-charge, was speaking to presspersons here on Thursday after reviewing the arrangements being made to hold a convention of Krishi Bhagya beneficiaries from 12 districts of north Karnataka, scheduled on August 29.

“Keeping in view the chronic problems faced by farmers in cultivating dry land, mainly due to vagaries of monsoon, the government introduced the scheme which was aimed at harvesting rainwater to protect crop during a crucial time through Krishi Hondas. In addition, under the scheme, farmers were provided with improved farm techniques by way of using advanced farm machineries and equipment to get more yield and also achieve economic growth.

The novel scheme of the government has not only won the appreciation of the Union government, which had sought all details of the scheme, but has also caught the attention of some of the neighbouring States which are now keen on adopting it,” he said.

Stating that the scheme has become very popular among farmers cultivating dry land, he said that the convention was being held to motivate other farmers to adopt the scheme and improve their economic status.

“Chief Minister Siddaramaiah will be inaugurating the convention and around 30,000 farmers from all over north Karnataka would attend it,” he said.

PHOTOGRAPHS



Construction of Farm pond and lining with the Geo membrane polythene



Use of Diesel Pumpset to lift the water collected in the pond



Use of Micro irrigation units irrigate the crop at different stages of crop growth



Construction of poly house and shade net





Shade net around the farm pond to avoid accidental deaths and evaporation losses

2.2. Importance of Siridhanya (Millets): In Drought Management

Department of Agriculture

Government of Karnataka

Introduction:

Karnataka is promoting millets as nutri-cereals that are good to eat and grow and kind on the planet. The perception of ragi (finger millets) and jowar (sorghum), the principal millets of the state, as food of the poor is changing mainly among those with lifestyle diseases. Karnataka has developed a brand called “Siri,” which means “rich” in Kannada, and is calling millets ‘siridhanya’ or rich grains. Karnataka started implementing distribution of millets through PDS -where the grains are sourced and distributed locally. Today, Karnataka is one of the leading producers and consumers of millets in the country. It also stands at the top of the market with a huge demand for millets. The state government is trying to make millets 'The Food of the Future' through various initiatives and ensuring farmers get their due remuneration. It is procuring Ragi & Jowar by giving a bonus of 20-25 percent above the MSP from farmers.

SMART FOODS – MILLETS

India is the largest producer of millets in the world, and accounts for more than 40 percent of the global consumption. Millet cultivation is the mainstay of rainfed farming which provide livelihood to nearly 50% of the total rural workforce and sustain 60% of cattle population in India.

Millets are most unique amongst cereals. Millets grow under dry conditions, can perform well with relatively poor soils and require low inputs. They are a staple food with superior nutritional qualities compared to other cereals. In India, for the poor, for instance among tribal people residing the highland areas of North East, and for farmers in dry areas including the Deccan, central India, western Indian states such as Gujarat and Rajasthan, and the western ghats, millets have long acted as a source of nutritional supplement. Used as dual-purpose crops (food and fodder), they make strong economic

sense in mixed farming systems. In addition, millets sequester carbon, thereby adding to CO₂ abatement opportunities, contribute to improved agro-biodiversity by their rich varietal diversity, allow for mutually beneficial intercropping with other vital crops, and have significant cultural value due to their long history.

Millet grains contain higher protein, fibre, calcium and minerals than the widely consumed fine cereals, and can ensure nutritional security to the poor people who cannot afford a variety of food items in their diet. A combination of factors like low remuneration as compared to other food crops, lack of input subsidies and price incentives, subsidised supply of fine cereals through Public Distribution System (PDS), and change in consumer preference (difficulty in processing, low shelf life of flour and low social status attached to millets), have led to shift from production of millets to other competing crops.

Millets are termed as the last standing crop in times of drought and as wonder grain that has a capability to enhance nutritional security in the country. Despite this, the consumption and cultivation of millets have been on the decline, greatly due to a lack of awareness around them.

Bringing millets into mainstream of agriculture and diet is the challenge ahead. Need of the hour is to focus on awareness, creation of consumption demand, enhancing cultivation, conservation and commercialization of small millets in an integrated approach is very much crucial.

A total of about 18 m tonnes of millet food grains are produced from nearly 16 m ha area, which constitutes 7% of national food grain basket. Bajra is grown in about 8.2 million hectares yielding 9.6 million tons, followed by jowar (6.4 m ha, yielding 5.9 m ton) and ragi (1.2 m ha, yielding 1.9 m ton) and other millets (0.7 m ha yielding 0.4 m ton). These crops are grown for both grain and fodder purpose. Much of the grains are consumed at household levels and the rest goes for industrial uses including for poultry feed, food processing and breweries. Some quantities are also exported as seed, bird feed and processed food items. At global level, India is the leading producer of millets producing 41% of bajra from 28% of global area under the crop and 7% of jowar from 13% of global area under the crop. Ragi, little millet and kodo millet are mostly grown in

India, whereas maximum area under foxtail millet (4-5m ha) is in China and proso millet is grown in Eurasian countries.

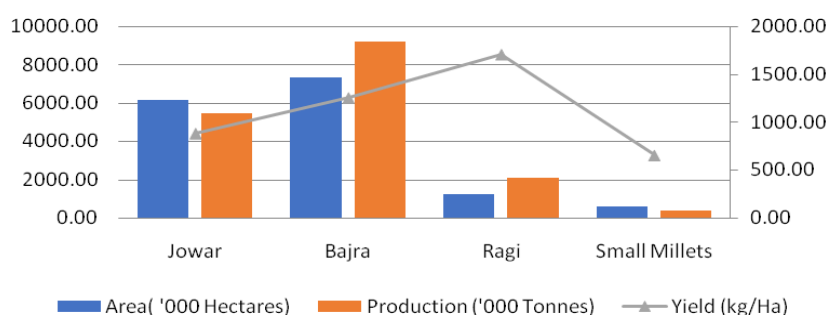
Millet crops are grown in low rainfall (200-600 mm) areas. These crops, being drought tolerant and highly adaptable, are highly suitable for dryland agricultural ecosystems and some of them are important in hill and tribal agriculture. Since centuries, the millets have provided food and nutritional security to the populations in the disadvantaged geographical regions. These food crops are unique as they require less water to grow, mature early and are cultivated in low input conditions. Agronomic advantages are that they are highly adapted to low rainfall conditions, able to withstand fairly long dry spells, recover fast after delayed rain, make them good contingent crops. Millets are highly resilient in adapting to different ecological conditions; ideal crops for climate change and contingency plantings. Being C4 plants these are more environment friendly with high water use efficiency and low input requirement, but equally responsive to high input management. Besides, being farmer-friendly, the unique nutritional properties of millets, i.e., high fiber, quality protein & mineral composition, being called as “nutri-cereals”.

Estimates of Area, Production and Yield of Millet Crops in India

Crop	Season	Area (million ha)	Production (million ton)	Yield (kg/ha)
Jowar	Kharif	2.53	2.85	1126
	Rabi	3.83	3	783
	Total	6.36	5.85	913
Bajra	Kharif	8.16	9.56	1172
Ragi	Kharif	1.2	1.95	1621
Small millets	Kharif	0.72	0.43	596
Total Millets	Total	16.45	17.79	1076

Source: Directorate of Economics and Statistics, GOI

The below figure depicts the area, production and yield of millets in India during 2014-15



[Source: Directorate of Economics and Statistics, GOI]

Though millets are one of the earliest grains that are being cultivated and consumed by the people, in the last few decades India and the world have witnessed significant decrease in the area under the millets crops. The total area, production productivity of jowar declined with CAGR of 4.4%, 5.8% and 1.4% respectively from 2010-11 to 2014-15. The loss in jowar area has remained more conspicuous since middle of 1980s at a rate of over 360 thousand ha per annum (Rakshit et al. 2014). The bajra area (7.3Mha) and production (9.2MT) also observed declined trend with CAGR 6% and 3.5% but productivity shown positive trend with CAGR of 3.1%. Ragi and other small millets also have shown similar declining trend in area and production with CAGR -1.1%, -1% and -7.7%, 3.2% but productivity observed slight positive growth of 0.1% and 1.2%. In India total area under the millets crops declined with CAGR of 5.4% annually from 2010-11 to 2014-15 and the production of total millets also declined at 4 % annually. Since the annual decline in the production was less than the loss of area under crops, the productivity of the millets witnessed slight increase in the last five years with CAGR value of 1.2 %.

Among the states, maximum area under millets is in Rajasthan (5 m ha; 87% under bajra) followed by Maharashtra (4 m ha, 75% under jowar) and Karnataka (2 m ha, 54% under jowar, 32% under ragi) .

Though India is the largest producer of millets in the world, between 1961 and 2012, there has been drastic reduction in the area under cultivation of millets but due to productivity gains in some varieties, total production of millets showed some increase despite shrinkage of area.

The main reasons for decline of the millets crops in India are low remuneration as compared to other competing crops, lack of input subsidies and price incentives, subsidized supply of fine cereals through PDS, and change in the consumer preferences (NAAS, 2013). These factors had led to shift from production of millets (jowar in particular) to other competing crops such as soybean, maize, cotton, sugarcane and sunflower in the country as a whole.

Millets are smart foods

- a. **Good for the consumer:** they can help overcome some of the biggest nutritional and health problems (iron, zinc, folic acid, calcium, diabetes and more);
- b. **Good for the planet:** they have a low water footprint, are able to survive in the hottest driest climates and will be important in coping with climate change, and more;
- c. **Good for the farmer:** can increase yields up to 3 fold, have multiple uses (food, fodder, fuel), and are typically the last crop standing in times of drought being a good risk management strategy for farmers.

Millets for the management of lifestyle disorders

Recent Research findings pointed that millets show anti-diabetic properties which is due to the presence of slow digestible starch (SDS) in good amounts, prolongs digestion and absorption of carbohydrates in intestine. Another study also points to the fact that blood glucose level showed considerable reduction of non-obese patients with non-insulin-dependent diabetes mellitus (NIDDM), who consumed sorghum bran papadi (Shinde, 2004).

Pearl millet is also proven to effectively help in maintaining the blood sugar level constant in diabetes patients for a long period of time. Finger millet based diets have shown lower glycemic response due to high fiber content and also alpha amylase inhibition properties which are known to reduce starch digestibility and absorption (Kumari and Sumathi, 2002). All small millets have been proven excellent anti-hyperglycemic activity (Sireeshaet *al.*, 2011; Park et al., 2008). Millet based foods also help to obtain better nutrition and as well as considered as preventive medicine for diabetes as they are also rich source of protein and other nutrients. Thus, millet consumption helps in the prevention and control of diabetes.

Consumption pattern of nutri-cereals

Sorghum and other millets are the staple food of western and central regions of Maharashtra and the northern region of Karnataka and Andhra Pradesh. The annual per capita consumption of sorghum is declined by 75% in urban areas, and 87% in rural areas during 1972-73 to 2011-12.

In the last two to three decades sorghum grain, especially sourced from kharif season are diverted to industrial uses such as livestock and poultry feed, starch, potable alcohol and ethanol production due to poor quality and mould affected grains.

The declining trend in sorghum consumption and other nutritious cereals in general is attributed to the shift in dietary patterns of consumption towards a balanced diet that includes livestock products, fruits and vegetables (Chand, 2007) which is mainly driven by an increase in income and urbanization wherein people are too busy to spend much time in preparation of their daily diet. Secondly, the shift is due to the consumption of fine cereals which are supplied through PDS at subsidized prices.

Bringing millets into Mainstream of Agriculture and Diet

Researchers, public policy advocates, government agencies and NGOs along with the millet farmers from across the country through their collective campaign and continuous dialogues with central government made it possible for millets and has given the focus they deserve; the coarse cereals of the dry land population of India to enter Public Distribution System(PDS) through a provision made for them in the Food Security Act, 2013. Several years of efforts made by the millet farmers and their demands to make space for their indigenous crops were thought to be fulfilled when the Act was made three years ago. However the act was unable to provide such status to millets as expected; except in the State of Karnataka.

While attention for millets is increasing, it is important to revitalize the nutri-cereals cultivation in the country. The only way is to have a focused and integrated approach to aim, strategize and implement the programme for doubling millet farmers' incomes. Various intervening points discussed in the previous sections are summarized below for

policy formulation to attain the underlying goal of doubling the millets farmers' income by 2022.

- ❖ **Firstly**, Given the inelastic supply nature of lands, significant income generation of millets farmers can be done by productivity enhancement of millets through reducing yield gaps, including fallow and wastelands under millets cultivation, improvement in TFP through technological breakthrough and development of HYVs and hybrids, development of bio-fortified millets varieties and establishment of seeds village/seed hubs.
- ❖ **Secondly**, millets farmers' income in dryland conditions can also be effectively increased by reducing the cost of production.
 - ✓ The cost of cultivation of millets can be reduced by adoption of recommended package of practices and increased resource use efficiency, technological upgradation and adoption of water saving technologies.
 - ✓ Resource use efficiency on the other hand can be increased by adopting conservation agriculture and blending indigenous and modern technologies of millets cultivation. Adoption of integrated farming system models with inclusion of millets for cultivation in post-kharif rice fallows will increase cropping intensity in dryland agriculture.
- ❖ **Thirdly**, generation of demand for millets is most important point to absorb the additional output generated with above mentioned ways. Generation of demand through value addition and millets sub-sector development will generate remunerative prices to the farmers and double millets farmers' income.
 - ✓ Value addition for demand creation can contribute up to 30% of additional income required for doubling millets farmers' income by 2022. Demand for millets and value-added products can be done through various policy advocacies.
 - ✓ Development of product specific varieties, creation of farm level grading and standards, fabrication of primary processing machinery and conducting bioavailability and shelf-life studies will create demand for millets in the

country. Setting up of nutrition-cum-referral labs on nutrition in IIMR will significantly contribute towards “branding of millets value chain” in the country.

- ✓ Addition of nutri-rich fodder in the millets value chain and other millets subsector development will significantly help in doubling the farmers’ income.
- ❖ **Fourthly**, by formulation of steady price policies, expanding the coverage of small millets under MSP, more procurement of millets through MSP and providing insurance coverage to all the nutri-cereal crop enterprises.
- ❖ **Fifthly**, creation of marketing infrastructure with innovative supply chain models, online marketing platforms and others will significantly increase the millets farmers’ share in consumer rupee.
 - ✓ Federating the millets farmers to form into FPOs will sufficiently increase the bargaining capacity of millets farmers. These FPOs need to be supplemented with provision for farm gate level processing of millets with technological backstopping from IIMR. The start-up entrepreneurs can be linked with FPOs for creation of innovative supply chain model and bringing remunerative prices to the millets farmers.
 - ✓ Thus the policies should aim at creation of FPOs with regard to millets with provision of small warehousing facilities for incentivising them to attain the goal of doubling the farmers’ income.
 - ✓ The horizon of contract farming can be explored under millets sector in the dryland parts of the country to provide price security to the farmers. This will also bring out timely and systematic supply of quality millets grains in the market.
- ❖ **Lastly**, improvement in the terms of trade (ToT) of agriculture, extending credit and insurance support to the farmers and providing tax exemption to the millets farmers and entrepreneurs will boost the millet farmers’ income and production in the coming years.

Karnataka: Reviving the Smart Grain

Department of Agriculture, Government of Karnataka making an effort in reinventing the past as millets had gone out of fashion and trying to make millets the food of the future through various initiatives and ensure farmers get their due remuneration as the crop can be grown with less water.

Sl.No	Name of the Millet	Kannada Name
1	Pearl Millet (<i>Pennisetum glaucum</i>)	Bajra
2	Foxtail Millet (<i>Setaria italica</i>)	Navane
3	Proso Millet (<i>Panicum miliaceum</i>)	Baragu
4	Finger Millet (<i>Eleusine coracana</i>)	Ragi
5	Indian Barnyard Millet (<i>Echinochloa frumentacea</i>)	Odal
6	Kodo Millet (<i>Paspalum scrobiculatum</i>)	Harka
7	Little Millet (<i>Paspalum sumatrense</i>)	Same
8	Sorghum (<i>Sorghum bicolor</i>)	Jola

3.1 ‘Sujala-3’- A World Bank assisted Science based Sustainable Watershed Management Model in Karnataka

**Prabhash Chandra Ray IFS, Commissioner Watershed Development Department,
Government of Karnataka and Project Director,
Karnataka Watershed Development Project-II (Sujala-3)**

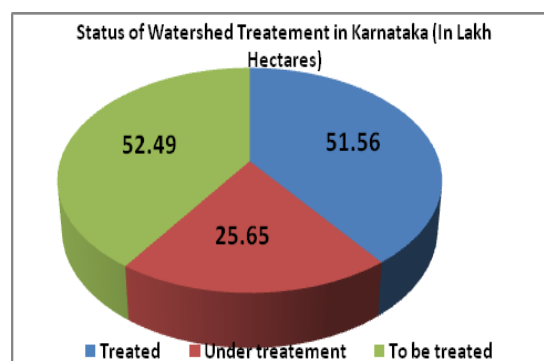
**&
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Watershed- A drought proofing solution

Watershed Development in India is reckoned as the engine of growth and sustainable development in rain-fed and drought prone areas. Watershed is considered as an ideal unit for the management of soil and land resources in achieving sustainable development. Watershed deterioration is a common phenomenon in most parts of the world. The major factors causing watershed deterioration are deforestation, improper land use, erosion, climate change and other anthropogenic activities. The result is manifested in the form of soil erosion, salinity/alkali, loss of forest and vegetation cover, and finally decrease in agricultural production in the watersheds. Therefore, it is necessary to develop a sustainable land management system for the watersheds that does not cause or at least prevent further degradation of such valuable resources.

Karnataka Watershed Development Department

Karnataka is the first State to create Watershed Development Department (WDD) in the country during the year 2000, with a multi-disciplinary team. Karnataka Watershed Development Department is the first State in the country to get the ISO 9001:2008 certificate for quality management system for the services rendered by the department. The mission of the department is to strive towards sustainable agriculture through integrated watershed management approach by



conserving natural resources such as soil, water and bio- diversity by adopting improved farm practices that are evolved through participatory process involving both scientific and indigenous knowledge system to empower the rural people to enhance their livelihoods. In the State, so far 51.56 lakh hectares area is treated with watershed activities using conventional methods of treatment and an area of 25.65 lakh hectares is under treatment. The remaining area of 52.49 lakh hectares is available for treatment in the days to come. Rain water harvesting programmes are being taken up exclusively with appropriate structures for recharging ground water and storing the surplus water for providing supplementary irrigation to crop growth. Till date about 53,000 water harvesting structures have been created in the State with a total capacity to harvest 407.32 lakh cubic meters of rainwater apart from in-situ moisture conservation through soil moisture conservation activities. A number of projects funded by different donor agencies including the World Bank are implemented by the Karnataka Watershed Development Department. Karnataka Watershed Development Project-II (Sujala-3) is one such project which is currently being implemented by the Watershed Development Department on a Science based approach.

Sujala-3 Watershed Development Project

The challenges posed by the continuing degradation and declining productivity of the resource base are very site specific and can be tackled only by addressing the concerned issues at the farm or watershed level by evolving a rational, site-specific and viable land use options suitable for each and every land holding at the village or watershed level. The required data for farm level planning can be obtained by carrying out Land Resource Inventory that describes and characterizes the nature of land resources, their constraints, inherent potentials and suitability for various land-based rural enterprises, crops and other uses for preparing location-specific action plans. Lack of such a database was mainly responsible for not so effective impact of many of the developmental schemes implemented in the past. It is with this objective, the Watershed Development Department of Govt. of Karnataka has initiated Karnataka Watershed Development Project-II, popularly called as Sujala-3.

Karnataka Watershed Development Project-II (Sujala-3) is a unique project to provide farm specific scientific advisory to the farmers for taking judicious decisions in conservation and management of natural resources such as soil and water, through the process of Land Resource Inventory (LRI), Hydrological studies and other socio-economic scientific studies. Sujala-3 is a World Bank assisted Project being implemented in the State with a treatable area of 12.66 lakh hectare across 2531 micro watersheds benefiting 9.60 lakh households. The project is being implemented from 2013 to 2018 with a budget outlay of Rs.527.67 crores.

The uniqueness of the project lies in the adoption of State of the Art technology for planning, implementation and monitoring. The Satellite Remote Sensing, Geographical Information System (GIS) are the core technologies which are extensively used in all the facets of the project such as data base generation, Land Resource Inventorisation (LRI), action plan preparation, implementation monitoring, and impact evaluation. Geographic information System (GIS) is also used for integrating spatial and non-spatial data which is further used as information database, analytical tool and decision support system. Effective use of technological tools such as land resource inventory, hydrological, hydro-geological, meteorological information in addition to Socio-economic survey for providing farmer friendly, field-tested, scientific and farm specific information to the farmers is the hallmark of Sujala-3 project. This science based approach is piloted and being successfully implemented for the first time in the history of watershed management in the country.

Detailed land resource database pertaining to the nature of the land resources, constraints, potentials and suitability for various crops is prerequisite for preparing location-specific action plans. LRI provides information required for watershed planning at 1: 7920 scale. The LRI maps are generated by studying site characteristics (slope, erosion, drainage, salinity, rock fragments etc. and soil characteristics (depth, texture, colour, structure, consistence, gravel, porosity, soil reaction etc). followed by grouping similar areas into management units. This is accomplished by using geo-referenced cadastral base in conjunction with high resolution Cartosat / Quickbird imagery.

For effective planning and management of the land resources, geospatial information on land Resource Inventory (physical and chemical properties of the soil, vegetation,

ownership and his socio-economic status) temporal information on Hydrogeology, weather, and market conditions is scientifically collected, analyzed, interpreted using and remote sensing and GIS and the information is shared with farmers through detailed Atlases and Advisories. These details are also shared with other developmental departments, organizations, institutes by hosting it on the web portal with enabling Decision Support System for taking judicious decisions in soil and moisture conservation, farming operations such as crop/variety selection, protective irrigation, integrated farming systems, integrated pest, diseases & nutrient management, timely harvesting, which will help in better marketing of the farm produce and thereby higher income realization to the farmers.

Scientific and Specialized Institutions, as Sujala-3 project partners

To accomplish the objectives of the project, services of various specialized institutional agencies are being used. The Land Resource Inventory work of 2531 selected micro- watersheds is led by National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) and five State Agricultural and Horticulture Universities. Hydrology and Hydrogeological studies are guided by Indian Institute of Science (IISc). Karnataka State Remote Sensing Application Centre is providing all the relevant cadastral maps, various types of satellite imageries of the watersheds under study. International Crops Research Institute for the Semi- Arid Tropics (ICRISAT) is assisting in organizing the capacity building activities of all the stake holders and arranging holistic demonstration of impacts of scientific watershed management in enhancing the productivity and income of the farmers. Livestock related aspects are spearheaded by Karnataka Veterinary, Animal Husbandry and Fisheries Sciences University (KVAFSU), Weather and climate related aspects are coordinated by Karnataka State Natural Disaster Monitoring Centre. Finally, Indian Institute of Soil and Water Conservation (IISWC) is entrusted with the task of monitoring and evaluation of the implementation and outcome of the project and its impact on the farming community.

Land Resource Inventory (LRI) in Sujala-3

Land Resource Inventory (LRI) for site-specific planning and development of watersheds is being carried out by using digitized cadastral map (Fig.1) and False Colour

Composites (FCC) of Cartosat-1 and LISS-IV merged satellite data (Fig.2). The methodology followed for carrying out LRI was as per the guidelines given in Soil Survey Manual. The FCCs were visually interpreted using image interpretation elements like colour tone, texture, pattern, association etc. along with all the collateral data available for the area. The delineated physiographic boundaries were transferred on to a cadastral map overlaid on satellite imagery and used as base map for mapping soils. Intensive traversing of each physiographic unit like hills, uplands and low lands was carried out. Based on the soil variability observed on the surface, transects were selected across the slope covering all the physiographic units identified in the watershed⁴. In the selected transect (Fig.3), soil profiles were located at closely spaced intervals to take care of any change in the land features like break in slope, erosion, gravel, stones, saline/alkali etc.

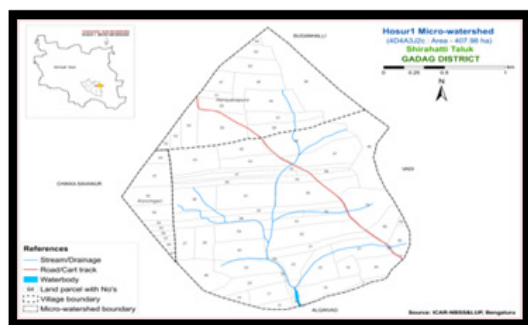


Fig.1 Scanned and Digitized Cadastral ap

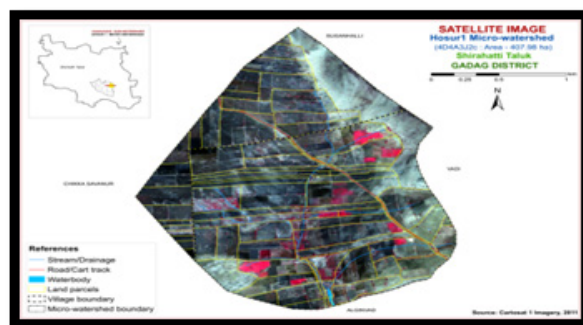


Fig.2 Cadastral map overlaid on IRS PAN+LISS IV Merged imagery

In the selected sites, soil profiles (vertical cut showing the soil layers from surface to the rock/water) were dug up to 200 cm or to the depth limited by rock or hard substratum. The profiles were studied and described in detail for all their morphological and physical characteristics. The soil and site characteristics were recorded for all the profile sites on a standard proforma as per the guidelines given in USDA Soil Survey Manual¹. Apart from the transect study, soil profiles were also studied at random, almost like in a grid pattern outside the transect areas to validate the soil map unit boundaries.

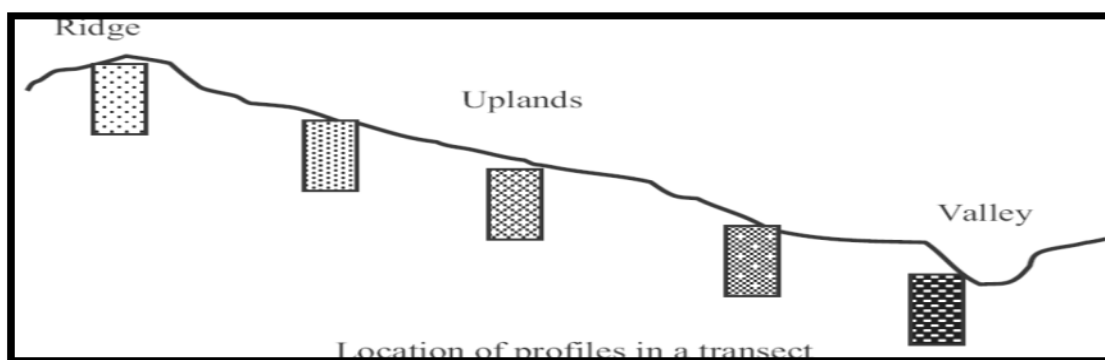


Fig.3 Location of Soil Profiles in a Transect

Based on soil characteristics, the soils were classified upto series level⁵ and grouped into different soil series. Soil series is the most homogeneous unit having similar horizons and properties, and behaves similarly for a given level of management. Soil depth, texture, colour, kind of soil horizon and its sequence, gravel, stones, calcareousness, nature of substratum etc. were used as differentiating characteristics for identifying soil series. The differentiating characteristics used for identifying soil series in the watersheds are given in Table 2. The soils were mapped as phases of soil series. The area under each soil series was further separated into soil phases (management units) by traversing each and every land parcel in all directions in the watersheds and their boundaries delineated on the cadastral map based on the variations observed in the texture of the surface soil, presence of gravel/stones, slope, erosion etc. A soil phase is a subdivision of soil series based mostly on surface soil features that affect its use and management. The soil mapping units are shown on the map (Fig.4) in the form of symbols. The soil map shows the spatial distribution and their area extent of different soil mapping units (soil phases) identified under each soil series. All the land parcels/survey numbers included in one soil phase will have similar soil and site characteristics that require same management and respond similarly for a given level of management. Soil samples were collected from representative master profiles for each soil series for laboratory characterization of physical and chemical properties by following the methods outlined in The Laboratory Manual⁶. Surface soil samples collected from farmers fields at 250 m grid interval were analyzed in the laboratory⁷ for fertility status (macro and micronutrients).

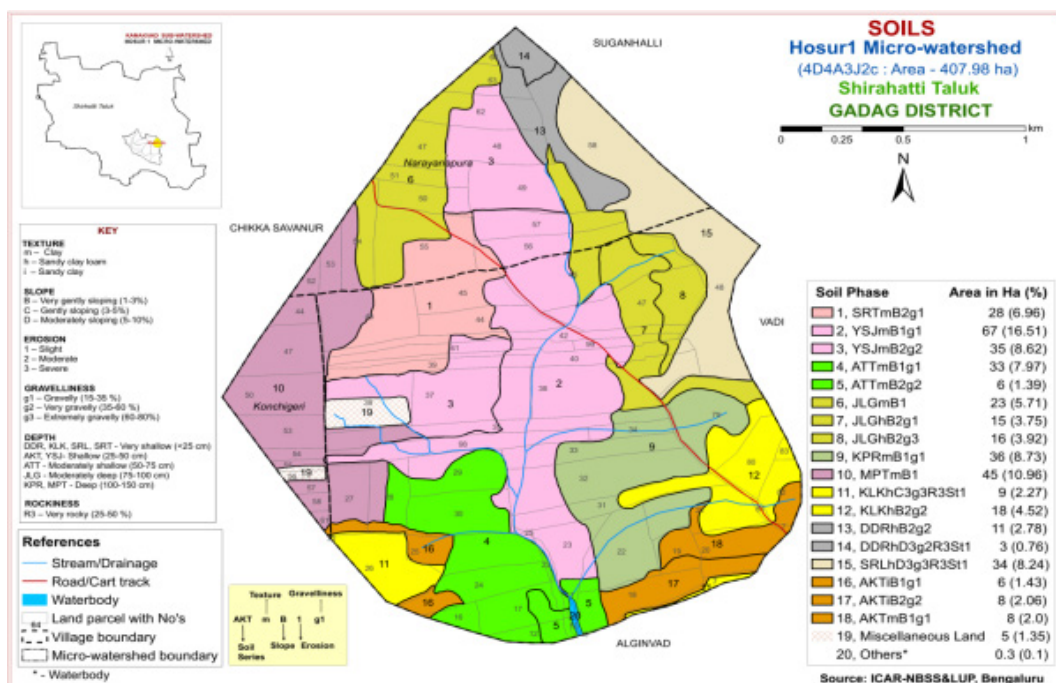


Fig.4 Soils (Phases of soil series)

Table 2. Differentiating Characteristics used for identifying Soils Series

Sl. No.	Soil Series	Depth (cm)	Colour	Texture	Gravel (%)	Kind of Horizon and its sequence	Calcareousness/others
			Series control section				
Soils of Granite gneiss Landscape							
1	Devihal (DVH)	<25	2.5YR 2.5/4 5YR 3/4, 4/6	cl	<15	Ap-Cr	-
2	Harve (HRV)	25-50	2.5YR 3/6 5YR 4/4	scl	>35	Ap-Bt-Cr	-
Soils of Basalt Landscape							
1	Atharga (ARG)	<25	10YR 2/2, 3/3, 3/4, 4/3, 4/4	sc-c	15-35	Ap-Crk	e-es
2	Karjol (KRJ)	>150	10YR 2/1, 3/1, 3/2, 3/3, 3/4, 4/1, 4/2, 4/3	cl-c	<15	Ap-Bss	es-ev

Interpretation of LRI Database

The LRI provides the required database and maps that are needed for addressing the complex issues at the micro level and more specifically to provide farm-specific crop

choices, evolve location-specific soil and water conservation measures, package of practices and to provide inputs needed for planning, implementing and monitoring of all land-based developmental programmes in the State, particularly the flagship programmes like PMKSY-Watershed Development program, Other Intervention, RKVY, Krishi Bhagya, Soil-Health Cards and Millet and Pulses development and Horticulture area expansion program etc. For this, the detailed spatial and non-spatial site-specific database required on various parameters that influence the use of land are generated through LRI and other socio-economic surveys for each watershed. Though the database is comprehensive, it cannot be readily used by the planners or farmers or any other land user, unless the scientific database is transformed as information that can be easily understood by different stakeholders. This has been achieved by interfacing RS, GIS, GPS with LRI databases and generating several interpretative and thematic maps like land capability, soil depth, surface soil texture, gravelliness/ stoniness, AWC, slope, erosion, soil fertility status for major (N, P, K) and micronutrients (S, B, Fe, Mn, Cu and Zn,) and soil pH and electrical conductivity. Land suitability for 27 major agricultural and horticultural crops grown in Karnataka were assessed by following FAO Framework for Land Evaluation^{8, 9, 10}. Soil and water conservation treatments required were assessed and treatment plans¹¹ were prepared for each micro-watershed identifying the sites to be treated and also the type of conservation structures required. Land Resource Atlases depicting 42 interpretative maps for each micro-watershed were prepared. These maps show the spatial distribution of both problem and potential areas with suggested interventions.

Significant Findings from LRI of Sujala-3 Watersheds and Suggested Interventions

Major findings of LRI has revealed that most of the watersheds have problems as well as potentials, which need different interventions to ensure production on a sustained basis. Some of the interpretative maps generated depicting different thematic areas for one micro-watershed are presented as an example in Figures 5a to 5n that help in planning of watershed development on scientific basis. The problems and potentials identified in general in all the micro-watersheds surveyed under Sujala-3 along with the suggested interventions are presented below.

Problem Areas

- The soils in the micro-watersheds are generally gravelly (>15-60% gravel). Gravel in the surface hinders seed bed preparation and seedling emergence, poor in soil moisture storage and nutrient availability, but are favourable for run-off harvesting. It plays a significant role in deciding the kind of crop to be grown.
- The soils are dominantly clayey and loamy at the surface. These soils are prone for sheet erosion, poor in water infiltration and percolation. They have high potential for soil-water and nutrient retention, and availability, problems of drainage, infiltration, workability and other physical problems. Such soils can be improved by sand mulching. A wide range of climatically adapted crops (food and horticultural) can be grown.
- Majority of the soils are low in available water capacity (<100 mm/m of soil). Only short duration crops can be grown and the probability of crop failure is high. They are best suited for other alternative uses such as pasture, agro-forestry or agri-hortilivipasture.
- About 50% area in the micro-watersheds are prone for sheet, rill and gully erosion. They need appropriate soil and water conservation and other land husbandry practices for restoring soil-health.
- The soils are alkaline (pH 7.3-9.0) in almost all the micro-watersheds except in Tumkur district, where the soils are mostly acidic to neutral (pH 5.1-7.3). For alkaline soils, regular addition of organic manure, green manuring, green leaf manuring, crop residue incorporation, mulching, application of bio-fertilisers, application of 25% extra N and P (125% RD N&P), application of gypsum once in three years and proper drainage will improve the soil-health condition. For acidic soils, application of lime based on the soil-test values will help to neutralise the soil condition.
- Most of the soils are low (<23kg/ha) in available phosphorus. Hence for all the crops, 25% additional P needs to be applied over and above the recommended dose.
- Generally, the soils are low (<10 ppm) in available sulphur, Such areas need to be applied with magnesium sulphate or gypsum or factamphos (P) fertiliser (13% sulphur) for 2-3 years for the deficiency to be corrected.

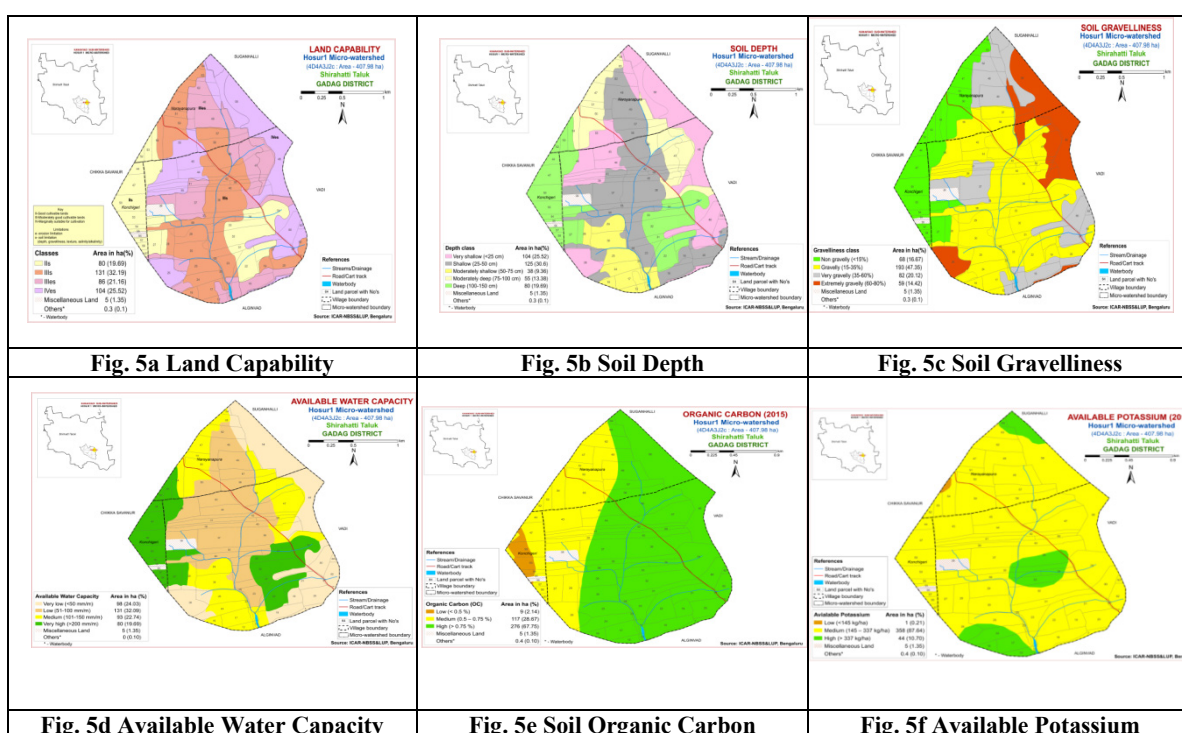
- Majority of the soils are deficient (<4.5 ppm) in available iron. To manage iron deficiency, iron sulphate @ 25 kg/ ha needs to be applied for 2-3 years.
- Most of the soils are deficient (<0.6 ppm) in available zinc. Application of zinc sulphate @ 25 kg/ha needs to be applied for correcting the Zn deficiency.
- Generally, the soils are low in (<0.5 ppm) in available boron. For such areas, boron @5 kg/ha needs to be applied for 2-3 years to correct the boron deficiency.
- Loss of forest and vegetative cover is one of the major causes of land degradation in most of the micro-watersheds. As part of the greening programme, it is recommended to plant a variety of horticultural and other tree plants that are edible, economical and produce lot of biomass to restore the ecological balance in the watersheds. The lands that are suitable for greening programme are non-arable lands (land capability classes V, VI, VII, and VIII) and also lands that are not suitable or marginally suitable for growing annual and perennial crops.

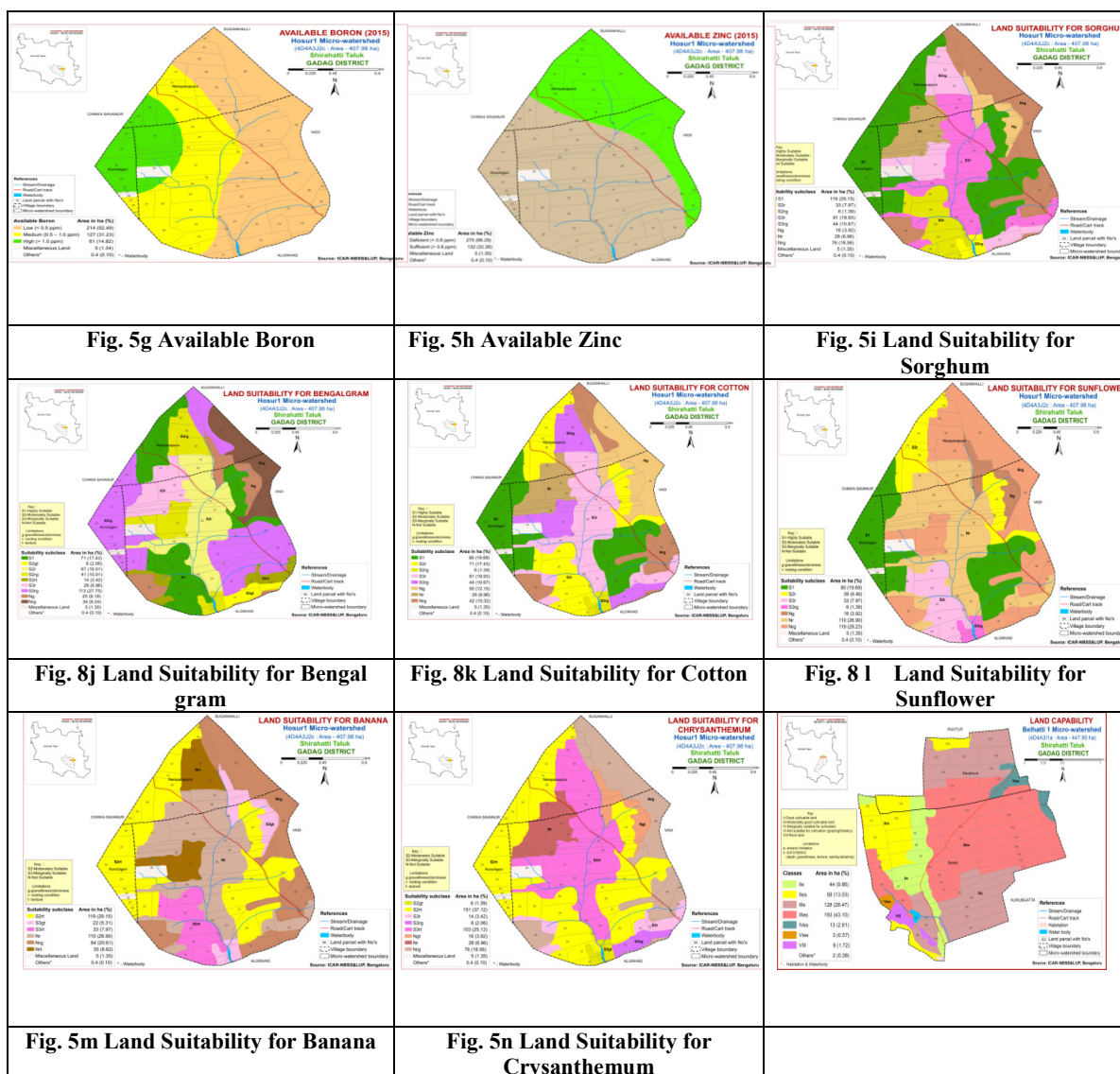
Potential Areas

- The soils are deep to moderately deep (>75-100 cm depth) in red soil micro-watersheds where all climatically adapted crops can be grown.
- Majority of the soils in the micro-watersheds are high (>337 kg/ha) in available potassium and as such may not require addition of potassium.
- Generally, the soils in most of the micro-watersheds are sufficient in available manganese and copper.
- Most of the lands in the micro-watersheds are suitable for agriculture with different kinds and degree of limitations and if attended to, then the production can be enhanced.
- About 50% area in the micro-watersheds are either moderately suitable or highly suitable for growing sorghum, maize, finger millet (ragi), red gram, horse gram, bengal gram, sunflower, groundnut, cotton, soybean, chillies, onion, guava, sapota, pomegranate, musambi, lime, amla, custard apple, jamun, tamarind, marigold and

chrysanthemum with various constraints/ limitations like length of crop growing period, soil depth, gravelliness, lighter/heavy soil texture, moisture availability, drainage, nutrient availability, erosion hazard etc. that are limiting the productivity. With suitable management interventions as recommended by the AICRP-Dry land Agriculture, the productivity can be enhanced.

The LRI database in the form of maps, illustrations, atlases and tables show different kinds of soils, their spatial distribution and extent, correlation, classification, characteristics and use potentials on an appropriate base map. It shows the problem and potential areas giving their spatial distribution and kind of limitation associated. It shows the areas suitable and not suitable for agriculture, horticulture, pasture, forestry, recreation etc, and identifies areas that need soil and water conservation and reclamation measures. It gives information on areas suitable for growing specific crops with limitations. It helps in identifying areas that are deficient or sufficient in major and micronutrients, thus facilitating preparation of soil-health cards for each land parcel/ survey no. for the crops intended to be grown. Finally, the LRI database helps in preparing optimum land use plans for the micro-watersheds that help not only in restoring the ecological balance but also in improving the production on a sustainable basis.





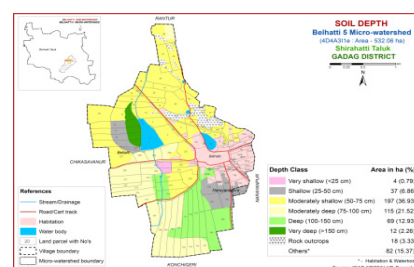
Utility of Land Resource Inventory Data in Drought mitigation

Several attempts have been made by meteorologists, hydrologists and other social scientists to identify the drought-prone areas taking into account mostly the climatic parameters. The ICAR-NBSS&LUP has made some effort to effectively integrate climatic and soil parameters that help in planning drought mitigation measures. In addition to climatic parameters, relevant soil and site conditions also need to be taken into account for identifying drought-prone areas as well as drought mitigation measures. Soil and site conditions play an important role in assessing the length of crop growing period (LGP), which is dependent on soil-site characteristics like topography, slope, drainage, infiltration, permeability, soil depth, texture, gravel content, AWC and mineralogy that influence soil moisture retention.

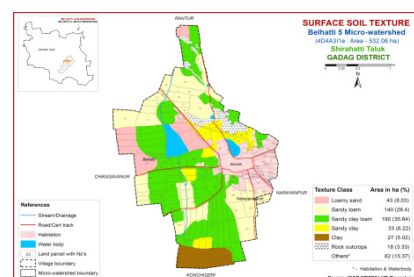
Land resource information generated through Land Resource Inventory (LRI) surveys in conjunction with climatic data help immensely in planning and implementation of drought mitigation measures. The major soil and site characteristics that are of relevance for management of drought-prone areas as well as drought mitigation are land capabilities, soil depth, soil texture, gravel content, soil available water capacity, soil slope, infiltration, permeability, drainage and soil mineralogy.

Land Capability: The land capability map shows the areas suitable and not suitable for general agriculture and the major constraints in each of the plot/survey number, thus helping one to decide what kind of enterprise is possible.

Soil depth: The depth of the soil determines the effective rooting depth for plants and in accordance with soil texture, mineralogy and gravel content, the capacity of the soil column to hold water and nutrient availability. The depth of a soil decides the amount of moisture and nutrients it can hold, what crops can be taken up or not depending on the rooting depth and the length of crop growing period available for raising any crop. Deeper the soil, better for a wide variety of crops that include long duration annual agricultural and perennial horticultural crops. If sufficient depth is not there, then go for short or medium duration crops or for other alternative uses.

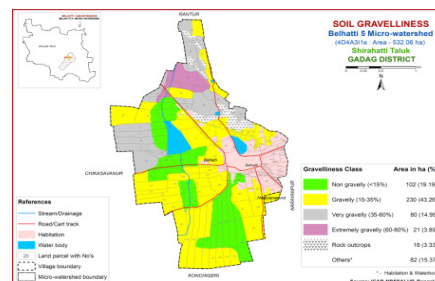


Soil texture: The soil texture has a direct bearing on the structure, porosity, adhesion and consistence. The surface layer of a soil to a depth of about 25 cm is the layer that is most used by crops and plants. The surface soil textural class provides a guide to understand soil-water retention and availability, nutrient holding capacity, infiltration, workability, drainage, physical and chemical behavior, microbial activity and crop-suitability. Lighter soil texture in the top soil means, better rainwater infiltration, less run-off and soil moisture conservation, less capillary rise and less evaporation losses. Light textured soils are amenable to good soil tilth and are highly suitable for crops like groundnut, root vegetables (carrot, potato, radish etc.) but not ideal for crops like paddy which needs stagnant water. Heavy textured soils are poor in water infiltration and

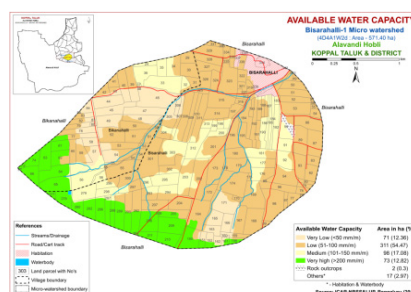


percolation and are prone to sheet erosion. Such soil can be improved either by sand mulching or addition of weathered parent material (rock). Heavy textured subsurface soils can hold more water and plant nutrients in the soil profile which helps in reducing the moisture stress for the growing crops.

Gravelliness: The presence of gravel and stones in soil reduces the volume of soil responsible for moisture and nutrient storage, drainage, infiltration and runoff, and hinders plant growth by impeding root growth and seedling emergence, intercultural operations and farm mechanization. More gravel content in the soil is favorable for run-off harvesting but poor in moisture storage and nutrient availability. It is a significant parameter that decides the kind of crops to be grown.



Available water capacity: The soil available water capacity is based on the ability of soil column to retain the water between the tensions of 0.33 and 15 bar in a depth of 100 cm or the entire solum. If the AWC is high (>200 mm/m of soil), then all climatically adapted long duration annual and perennial crops can be grown. If AWC is low (<100 mm/m soil), then it will be ideal only for short duration crops or for other alternative uses.

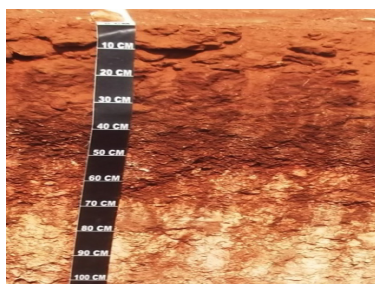


As an example, some micro-watershed maps along with photographs are presented to indicate the wide variability prevalent within a small area of 500 ha with respect to land capability, soil depth, soil texture, gravelliness and AWC. This database in the form of maps and map legends will help in formulating drought mitigation measures for each of the land parcel.



Arable land (LCC II,III,IV)

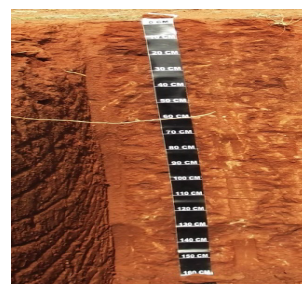
Non-Arable land (LCC V, VI, VII, VIII)



**Shallow Soils
(25-50 cm)**



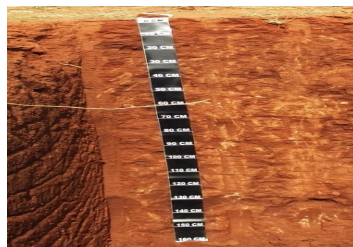
Moderately deep soils (75-100 cm)



Very deep soils (>150 cm)



Sandy Soils



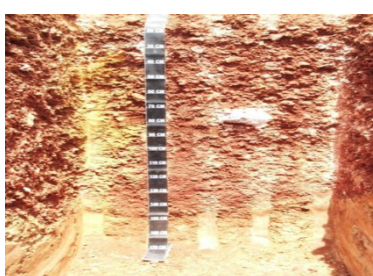
Loamy soils



Clayey soils



Non gravelly (<15%) Soils



Very gravelly (>35%) soils



**Very severe – Carpet of
Gravel and stones**



Very high AWC (>200 mm/m)



Low AWC (50-100 mm/m)

Weather Information to Farmers

In order to provide precise weather related information, forecast and advisory to the farmers for planning agricultural activities and to minimize crop loss due to adverse weather conditions, automatic weather stations are set up in every hobli. Rainfall information at every 15 minutes time interval is captured at every Gram Panchayath/ micro watershed (500 ha area). In addition to this, weekly rainy days, daily temperature,

relative humidity, evapo-transpiration, mean wind speed etc are captured are recorded and effectively used in the project. A 24 X 7 interactive help desk is available to farmers for seeking the information under Varuna Mitra program.

Hydrological Information to Farmers

The hydrological instruments are installed at 14 selected model micro-watershed level to get periodical hydrological information and to support hydrological studies. In addition to this, the imageries from RIOSAT-1 and SMOS satellite with a spatial resolution of 500 m and temporal resolution of one day is used. The agro-hydrological parameters measured and monitored include Soil moisture (surface and profile), Groundwater levels, Bore well Discharge and yield, Water quality (chemical & physical)- surface & groundwater, Canopy variables (LAI, Biomass, crop yield, crop management activities).

Hydro-geological Information to Farmers

In addition to hydrological parameters, hydro-geological parameters are also studied and used in the project. Pumping test equipments are installed in the watersheds to undertake different hydraulic tests such as slug test, pumping test to estimate hydro geological parameters of hard rock aquifers like Hydraulic conductivity (K), Transmissivity (T) and Storability (S).

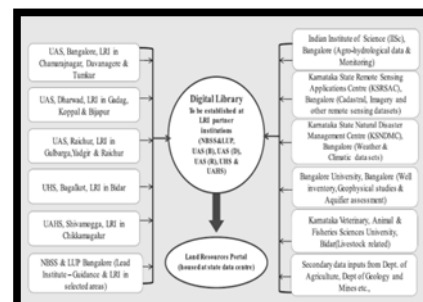
Technological Application for Baseline Survey

Technological application for socio-economic survey is yet another feature of Sujala-3 where the baseline information from the farmers is collected using a customised software. This particular software is not only used for collecting information from the farmers but also for analysis of the data and providing instant reports. The major indicators of socio-economic survey includes Status of health and education, Household income, Crop production and Productivity, Copping pattern, ownership of assets,

membership in community based organisations such as SHGs, User groups and functioning of community based organizations etc.

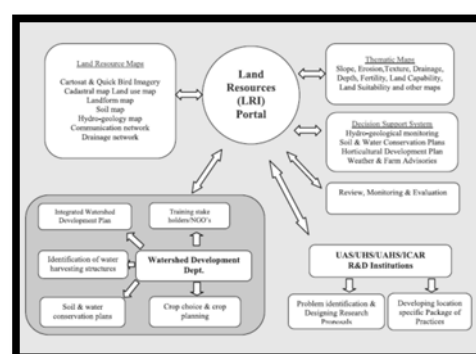
Establishment of Digital Library & DSS

All spatial and non-spatial datasets generated at watershed/village level under LRI are first converted into digital form, then integrated in a GIS framework and housed in the Digital Library to be established in each of the five Universities to cover the entire State and later made available to the various line departments and developmental agencies on a real time basis through Land Resources Portal. This data handling system, its storage, retrieval, analysis and display capability and easy accessibility will be a very valuable tool to the planners, administrators, researchers, extension workers for making land use decisions and for providing proactive advice to the farmers on real time basis.



Information Dissemination through Land Resources Portal

The Land Resources Portal helps in the dissemination of information to the line departments, administrators, researchers, NGO's and will also provide the required up-link facilities to the farm families required for day to day information needs to manage their resources at farm level. This will be a one stop Portal, which is expected to provide not only the required information to all the stakeholders, but also to enable the users to benefit from the interactive and dynamic mode of operation. Apart from this, all kinds of queries during or before the execution of any land-based project can be put on the web-based Decision Support System (DSS) and needed solutions can be obtained by the developmental agencies as well as farmers in the State on a real time basis. State-of-the-art Digital



Library and their link up with all user agencies at different levels through the commissioning of the Portal, supported by a dynamic DSS is expected to change the entire process of planning, which in most of the cases at present follow a top down approach rather than of grassroots and bring in a paradigm shift by facilitating a two way planning process in addressing the site-specific problems faced by farmers.

Replication of Sujala-3 model outside the State

The successful model of Sujala-3 has also spread outside the State. Officers from nine other states from India visited Karnataka State to study and replicate the Sujala-3 model. So far about 112 officers across different States of India visited Karnataka to study the Sujala-3 model. The visiting States include Andhra Pradesh, Telangana, Chattisgarh, Madhya Pradesh, Gujarat, Jharkhand, Maharashtra, Odisha and Rajashthan. These States also got impressed by the model and similar model is being replicated in those States. World Bank is also taking Karnataka LRI experience for Neeranchal Watershed Project spread over several states.



Replication of Sujala-3 model outside the Country

Twenty three international delegates from 14 countries namely Afghanistan, Afghanistan, Egypt, Ethiopia, Iraq, Kenya, Mauritius, Niger, Nigeria, Palestine, Sri Lanka, Sudan, Tanzania, Tunisia and Zimbabwe visited Karnataka State during September 2017 to study the Sujala-3 model. The visitors expressed highest satisfaction about the technological tools and science based approach used by Sujala-3 watershed development project to provide farm specific advisory for watershed development and doubling farmer's income.



Hence, Suajal-3 project has emerged as successful, replicable, scientific and technology driven multi-sectoral and participatory watershed management model in Karnataka; benefiting farming community, planners, researchers, technical organizations

and implementing organizations in terms of efficient utilisation of resources, effective planning and to reap optimum Socio-economic, ecological and environmental benefits. This science based sustainable model is worth replicating in other parts of the world for better management of watersheds for resource sustainability and effective drought proofing, which will increase productivity and reduce poverty in rainfed drought prone areas.

3.2 Drought Management Strategies and Best Practices adopted to Mitigate Drought - A Journey Towards Sustainability

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Karnataka state is predominantly agriculture based with more than 70% of its population depending on agriculture and its allied activities. The average annual rainfall of Karnataka varies from 508 to 5051 mm. Total Geographical area of state is 190.50 lakh ha. Out of which 129.70 lakh ha. area available for watershed interventions. So far 65.34 lakh ha rain fed area is brought under watershed interventions. The remaining area of 52.49 lakh ha. is planned for scientific watershed interventions in a phased manner.

Karnataka state watershed development approach/interventions has been widely acknowledged for its effective, community based and use of scientific tools to address the needs of rain fed agriculture and also to mitigate the frequent drought in the rain fed areas of the state.

The community based drought management strategies of the state is being widely adopted by the many states of the country.

Mitigation of Drought through Natural Resource Conservation

Arable land treatment

Contour Bunds: These are trapezoidal earthen or loose-boulder embankment constructed on contour. These bunds intercept runoff and hold the water for subsequent absorption and there by conserve soil and moisture. Waste weirs are normally provided by using loose stones properly embedded in soil to avoid scouring / under cutting and to drain the excess water accumulated against bund.



Field bunds:

These are the earthen embankments constructed along the boundary lines of the individual farmers plot to conserve the soil and moisture in his plot itself.

Trench-cum-pit method of bunding:

It is a newly evolved bunding type, where in the earthen embankments constructed with a 5 mtr length x 1 mtr width x 0.6 mtr depth trenches & by leaving 0.6 mtr berm in between each trenches. More runoff water can be stored, there by more water is infiltrates into the soil and provides moisture for more periods to the development of vegetation.

**Contour strip:**

Contour strip formed in the areas where rainfall is less, gentle slope with less infiltration. This is to increase the moisture infiltration rate. Within the two contour strips small size bunds with bund former are also made.

Boulder bunds:

This is a bund across the slope constructed by using locally available stones / boulders in the sand mixed soils and in the shallow soils. This is an alternative to the contour bund, where there is no enough soil to form bunds.

Graded bunds:

These are trapezoidal earthen embankments constructed on grade across the major slope. These bunds are taken up in areas receiving annual rainfall of more than 750 mm, where runoff is high & surplussing is essential.

Vegetative bund/ Vegetative check:

A live vegetative barrier on the contours is made which will decrease the velocity of rain water in turn soil erosion is controlled. These checks could also be formed in between the contour bunds also.

**Water ways:**

These are formed along the slope for safe disposal of excess rain water from cultivable areas to nalas. Grass is also grown in the water ways to avoid further scoring.

**Farm ponds**

Farm ponds are opened across the water ways by digging the soil. The excess rain water is harvested and the harvested water is used for various activities like giving protective irrigation to vegetables & orchards including drinking water to animals and birds.

**Non-Arable Land Treatments**

Treatment of non-arable land has been inevitable to reduce the runoff and to create water storage at field level. They help to distribute moisture uniformly on sloping land so that natural vegetation grows successfully and restores the bio-diversity.





Contour Trench / 'V' ditches:

These are trenches / V-ditches dug on contour in non-arable lands of more than 3% slope to hold run off for conservation and reducing erosion. They are established for development of trees and grass species and are adoptable in areas with annual rainfall of up to 950 mm.

Pits with Crescent - shaped bunds:

These consists of staggered rows of pits with crescent-shaped bunds for planting trees and are adoptable in non-arable lands having less than 3% slope in areas with annual rainfall of less than 950 mm.

Catch pits:

These are large pits dug at rill points and in waterways to trap runoff water. They are adoptable in hilly lands with rock outcrops.

Continued contour trenches:

Trenches are opened at a distance of 5 to 10 meters with 0.45 meter depth and 0.6 meters width in the areas where annual rainfall is less than 750 mm. The rain water is collected in the trenches and then the plants could be planted.



Staggered contour trenches:

These are opened where there is undue soil slope with humps.

Graded contour trenches:

These trenches are made in the black soil areas where rainfall is more than 750 mm, for safe disposal of excess water and forest plants are planted.

Vegetative filter strips:

These are made to reduce the velocity of rain water coming from hills, forest area across the slope at intercepting areas where cultivable and uncultivable areas joins. Once the vegetative strips are grown fully it will act as a barrier to check the flow of water from slopes and soil erosion is controlled. The locally available Agaves, lavancha, Jatropia, Pongamia etc could be used as veg checks.

**Water recharging pit:**

The pit is opened in the uncultivable area in the direction of diversion channels / water ways or near by areas where there is flat lands. Dry stone pitching on the three sides of up stream side also be done.

Diversion channel:

Diversion channel is formed to avoid the rain water that flows from pasture lands, hills areas, and forest areas into the cultivable area. A drain across the slope is opened for safe disposal of water.



3. Drainage line treatment

3.1 Upper reaches treatment

Vegetative checks:

Sod-forming grasses like *Cynodon dactylon*, *Digitaria* & *Dicanthium* are planted. In some cases trees and shrubs such as *Ipomoea cornea*, *Vitex nigundo*, agave, *Saccharum munja* & bamboo are also recommended.



Vegetative filter strips:

These are made to reduce the velocity of rain water coming from hills, forest area across the slope at intercepting areas where cultivable and uncultivable areas joins. Once the vegetative strips are grown fully it will act as a barrier to check the flow of water from slopes and soil erosion is controlled. The different types of filter strips are sod strips, sodded earthen strips & shrub checks. The locally available Agaves, lavancha, Jatropia, Pongamia etc could be used as vegetative checks.

Boulder checks:

These are porous checks across the nala constructed using boulders to check water velocity and to arrest silt.



BOULDER CHECKS AT BAGDAL VILLAGE, BIDAR TALUKA, PMKSY WD 2016-17

Rubble Checks:

Rubble check is constructed where the gully width is upto 10 meter and depth is 1 to 3 meters with a vertical interval of 2-2.5 meters. The catchments area considered is from 8 to 15 hectares. This should also serve to control soil erosion and silt flow. Agaves row could also be planted on up stream and down stream side at a distance of 0.3 meters.

Brush wood checks:

These are porous checks constructed across the gully with wooden pegs and brush wood and are adoptable in all areas.

**Gabions:**

These are dams made of wire-woven baskets filled with stones placed in trench of suitable size across steep-sloped gullies to trap erosion debris during rains. They are adoptable in all areas of high slopes and high rainfall.

Water recharge pit:

Pit is opened in the soils where there is less water infiltration rate. The pit is opened in the gentle slope nalas / gullies where the upper reaches are already treated and so there is less scope of siltation. These should be opened preferably adjacent to open / bore wells.

**3.2 Middle reaches treatment:****Dry stone checks/ Rock filled dam:**

These structures are constructed where there is no necessity of impounding more water and to avoid further scoring. They are constructed at the points where gullies join and gullies of serious nature. The availability of stones should be within 40kms distance.

Small sunken ponds:

The rain water that would have flown in gullies will be sorted so that the moisture percentage around the cropped area is increased. The excavated soil is put as bund so that water storage is increased.



Ravine

Reclamation structure (RRS):

is a masonry structure consisting of a body wall, apron and header. The banks are protected by stone revetment to further scouring. They are constructed to control head movement of gullies, avoid further widening and deepening ravine. Reduce sedimentation of tanks/reservoirs to provide protective irrigation, drinking water for the cattle and wild life, increase



moisture regime and recharge underground waier table. They are constructed in ravines with depth of 2.5 to 3.5m width 8 to 15m and catchment area 15 - 25ha

3.3 Lower reaches treatment:

Check dams:

These are stone masonry structures constructed across deep nala with the objective of controlling runoff water, reducing sedimentation of tanks/ reservoirs, providing protective irrigation, drinking water for the cattle and wild life & to recharge underground water table.

Vented dam:

Cement masonry work taken up in the high rainfall area. The vents are provided to allow the water flow during the rainy season and store water after the decrease in rainfall. Wooden Flanks are provided to close the vents. The stored water is used for irrigation.



Nala bunds:

This structure consists of homogenous earthen embankment constructed across the nalas / valleys in arable & non arable lands to store run-off for recharging ground water & make water available for social & agricultural use at surface level.



Percolation tank:

This is also Nala bund but with stone, cement masonry out let to drain the excess water. This is opted where there is less scope for cut out- let.

Alternative Land use Systems Dry land Horticulture:

This is the practice of cultivation of perennial fruit crops and is adoptable in marginal and sub-marginal lands of private holdings in all areas. The space between trees could be used for cultivation of crops (Agro-Horticultural system) during the initial years till the canopy is fully developed, after which share loving grasses and legumes (Horti - pasture system) may be grown for better utilization of the land.



Agro-Horticulture:

This is the practice of cultivating perennial fruit crops along with annual crops & is particularly useful in marginal & sub-marginal lands. The fruit species are to be planted in the water-receiving areas

of zing terraces, on boundary bunds & on the inner bunds with wide spacing so as to allow cultivation of annual agricultural crops.

Agro-forestry:

It is the system of growing woody perennials along with annual agricultural crops and is applicable in all areas. The trees are planted on field boundaries and along the inner bunds, preferably those running east - west to avoid shading. A density of 10 to 100



plants per ha is maintained. The woody perennials selected should have economic value in terms of fodder, green manure, fuel, fiber and timber. The perennials should be maintained by lopping the side branches to reduce competition with companion crops.



Block plantation (Afforestation & Reforestation):

Rising of forest trees on lands which were not covered with forest and were reduced to scrub due to biotic interference. This may be under taken to (a) conserve Soil & Moisture in denuded bare lands, Sand dunes, Ravines & other wastelands (b) to meet the local demands for economic utilization of land (c) landscape for recreation and conserving flora & fauna.

Fodder development

Fodder development activities on field bunds as well as common lands are being taken and also silage pits are constructed to store the fodder for longer duration and value addition.



3.3 Drought Proofing Dry Land Livestock Farming – Experiences of KVAFSU under Sujala-III Watershed Project

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Karnataka Watershed Development Department is implementing the World bank funded Karnataka Watershed Development (KWDP-II; Sujala-III) project in seven selected districts of Karnataka at an estimated cost of 85.70 million USD spread over five years covering an area of 2,08,660 ha. The project has a focus on integrating watershed development activities with all other land-based research and developmental programs. This would help rain fed farmers access a range of information tools, adopt innovations and diversify crop, horticulture and livestock production and improve the value chain through Best Management Practices within their particular farming systems. Considering the role of livestock in providing livelihood to rural masses, KVAFSU, Bidar is identified as one of the 13 consortium partners and is assigned with the task of carrying out the livestock based research and extension activities through participatory research approaches.

The project is undertaken from December, 2014 in seven districts of Karnataka viz Bidar, Chamarajnagar, Davanagere, Gadag, Gulbarga, Koppal and Yadgir. The project is implemented in selected 524 micro watersheds in two phases covering 2, 52, 687 ha (Phase I – 2910, MW – 140186 ha), Phase II 233 mw- 1, 12,501 ha) spread over nearly 163 gram panchayaths with an overall objective / purpose *to demonstrate more effective watershed management through greater integration of programs related to rain fed agriculture and allied activities, innovative and science based approaches and strengthened institutions and capabilities of stakeholders at different levels.*

The specific objectives of the project are:

- To identify existing problems / critical gaps and formulating best management practices related to livestock and fisheries.

- To organize capacity building activities on identified best management practices in project area.
- To provide inputs for livestock/fisheries development activities for Watershed development planning.
- Genetic improvement of small ruminants.

Critical Gaps and Identified Interventions:

An initial baseline survey in the seven project districts has paved the way for identifying critical gaps and introduces technological interventions in the project area to improve the various livestock production systems.

Table 1. Critical Gaps and Identified Interventions for Livestock Development

Dairy Production/Rearing System	
Critical Gaps	Identified Interventions
Low productivity	• Promoting balanced feeding • Increasing green fodder availability
Green fodder shortage	• Promoting High yielding fodder varieties cultivation • Introducing fodder trees like <i>Sesbania</i> and <i>Moringa</i>
Fodder wastage	• Promoting enrichment of dry fodder • Introducing chaff cutter • Promoting construction of Manger
Lengthy inter-calving period and delayed age at puberty	• Creating awareness and improving breeding facilities • Providing proper feeding and balanced ration • Organizing regular health and infertility camps
Others	• Promoting construction of Cattle sheds • Regular deworming based on faecal sample analysis • Training/Awareness programs
Goat/Sheep Production System	
Inbreeding	• Changing breeding ram/buck
Poor kidding & twinning rate	• Supplementary feeding during breeding and lambing/ kidding season/transition period
Kid and lamb mortality (20-25%)	• De-worming based on faecal sample analysis • Supplementary feeding during transition period
Unscrupulous marketing system	• Introduction of weighing machine
Others	• Training/Awareness program

Technical interventions undertaken under the project:

To address the above mentioned critical gaps, technical interventions were introduced in consultation with the technical experts, field functionaries and farming community. Some of the interventions addressed in the project area are:

- Establishment of fodder nurseries
- On-farm demonstration of silage production through silo bags
- Demonstration on fodder enrichment and fodder chaffing
- Demonstration of preparation of balanced ration
- Diagnosis and control of subclinical mastitis
- Designing and development of equipment for handling Downer cows
- Demonstration sheds for summer management of buffaloes
- Introduction of improved breeds of bucks and rams to avoid inbreeding
- Demonstration unit for stall feeding of goats
- Supplementary feeding during transition period in goats
- Establishment of rural hatcheries
- Awareness programs to address the knowledge gaps
- Production of extension literature and documentaries

Experiences of KVAFSU with regard to drought mitigation:

Out of the various critical gaps identified those related to fodder production and feeding were common across the different production systems - dairy, sheep and goat. Technical interventions, viz, establishment of fodder nurseries, silage making by using silo bags; enrichment of dry fodder and integration of fodder and fodder trees in horticulture crops and farm ponds are being carried out in all the watershed areas of the project and the results are encouraging. These demonstrations though carried out in small scale and in isolation, have demonstrated the ways of how to mitigate fodder scarcity in summer season. From the accrued experiences of implementing the above activities a five pronged strategy is recommended for drought proofing small, marginal and other livestock farmers in dry land regions.

- I. Emphasis on green fodder production in rainy season
- II. Green fodder grown in rainy season is preserved as silage for summer season.
- III. Dry fodder available with the farmer is chaffed, enriched and used for animals
- IV. Fodder trees shall be cultivated all along the bunds of the farmer's fields.
- V. Locally available non-conventional feed & fodder resources be utilized judiciously



Fig 1: Five pronged strategy for drought proofing livestock farming in dry land regions.

I. Emphasis on green fodder production in rainy season:

Green fodder availability is good in rainy season. Normally farmers graze the animals all along the roads, common property resources, etc. Likewise, the weed grasses obtained after de-weeding the crops is fed to the animals. Few farmers even grow green fodder specifically for fodder but the utility is restricted to that season only. However, farmers growing green fodder for future use is absent, except for those having irrigation and growing perennial grasses. In this context, farmers need to be encouraged to grow green fodder, preferably, maize or sorghum for future use. A minimum area of 4-5 guntas allocated to these fodder crops would yield about two tones biomass which can be converted into silage. This would suffice for two dairy animals to tide over the summer. The farmer alternatively can intercrop with other crops to obtain the same quantity of fodder.

Simultaneously, drought resistant multi-cut sorghum varieties like COFS29/31 can also be grown in few guntas to supplement this. These varieties will grow well during

showers and moisture availability and remain dormant during dry spells. Those who are having irrigation facilities can go for perennial hybrid napier like DHN6, CO4/5. Horticulture crops can be intercropped with guinea grass, stylosanthes, hedge Lucerne, etc.

II. Green fodder grown in rainy reason should be preserved as silage.

So grown green fodder should be harvested in right stage and silage prepared. No additives are needed if the fodder is harvested during right stage. Milky grain stage is ideal one. Good compaction and air tightness is a must. Silage may be prepared either using silo bags or plastic drums. Two silo bags of about one tone capacity each will hold about 1.5-1.6 tonnes of fodder. These bags can be opened in lean period – February to May. Daily use of about 16 kgs silage for two dairy cows would last for minimum of three months comfortably. Alternatively, commercially available plastic drums of 200 litres can hold about 100-110 kgs of fodder. In such case about 5-6 drums per cow can hold silage sufficient for about two months very comfortably.



Chaffing of green fodder



Silage making using drums



Silage making using silo bags

Dry fodder available with the farmer should be chaffed, enriched and used for animals

Feeding dry fodder is essential in any ruminant production system. It is essential to provide dry matter required for the animal, fill the stomach, improve the fat content in milk, etc. Further, majority of the livestock production in Indian is based on agricultural waste, viz, straw, stovers, husk, etc. In most of the Sujala project watershed areas jowar /maize stover based feeding is predominant. Experiences of farmers and observations in the field indicate a loss of 30-40% dry fodder just because of not chaffing it. Hence, the

practice of chaffing of dry fodder alone amounts to enormous saving of scarce resource and renders the fodder for value addition in the form of urea enrichment. This would raise the crude protein level from almost zero to 5-6% in addition to making the fodder soft, palatable and reducing the wastage to almost nil. Hence, dry fodder available with the farmer should be enriched by **urea ammoniation** method. Initially enrichment may be done in two silo bags. Each silo bag of one ton capacity would hold about 250 kgs of chaffed dry fodder. Daily use @10 kgs for two cows would last for about three weeks from one bag. The empty bag may be further nsiled subsequently.



Enrichment of dry fodder



Enrichment using drums



Enrichment using silo bags

III. Fodder trees should be cultivated all along the bunds of the fields.

The only way to ensure green fodder in summer to all types of farmers, especially dry land farmers, is by cultivating fodder trees. They are the emergency fodder banks. For an initial care of them for a year or so they would reciprocate by giving fodder for many years to come. Smaller straight growing fodder trees like sesbania, drumstick, erythrina, mulberry can be grown on the internal bunds. Bigger fodder trees, namely, *Melia dubia*, Subabul, *albezia*, etc., can be grown all along the outer borders. The trees should be mercilessly lopped periodically so that they yield higher biomass per year. In an acre of land very comfortably more than 300 such trees can be grown. Two cows can be fed about five kgs of green fodder daily. The farmers can prepare their own nurseries and plant them in rainy season when climate is cool and moisture is good in the soil. Alternatively few farmers can be trained to raise the saplings and sell them to fellow farmers. Otherwise, Forest Dept. can help in supplying the saplings.



Nursery of fodder tree plants

Fodder tree plants integrated with farm ponds

IV. Locally available non-conventional feed & fodder resources should be utilized.

All available non-conventional feeds, such as maize cobs and sheath, sunflower heads, banana stems, spineless cactus, azolla, areca sheaths, sugarcane tops & trash, etc, be used as feed resources. Research findings have shown that maize cobs and sheaths, sunflower heads, areca sheaths can be used in feeding animals. Even supply of areca sheath powder as feed source has been commercialized. Likewise, use of spineless cactus is a very crucial feeding strategy in drought prone regions of Africa and is being popularized by Central Sheep & Wool Research Institute, Avikanagar. Silage making using sugarcane tops has been standardized. Hence, based on the locally available resources such ingredients may be used in feeding livestock in drought situations.

Need for chaffing facility at village level: Mechanization of farming operations is the order of the day for reasons such as advent of science and technology, shortage of labour, etc. Of late, harvesting of paddy, thrashing of paddy, ragi, jowar, maize, etc, is almost done by machines, either tractor or diesel operated. These machines are moved to farmers' doorsteps and are charged on hourly basis. They are owned by innovative farmers or entrepreneurs who use them for their own farm operations and rent out in other period.

Use of commercially available silo-bags, plastic drums, etc, has thrown open opportunities for every farmer including small and marginal and landless labourers to conserve green fodder and enrich dry fodder. However, chaffing of fodder, either green or dry becomes pre-requisite for fodder enrichment and silage making. Hence, facility for chaffing at the doorsteps of farmers is a must for this type of management revolution in

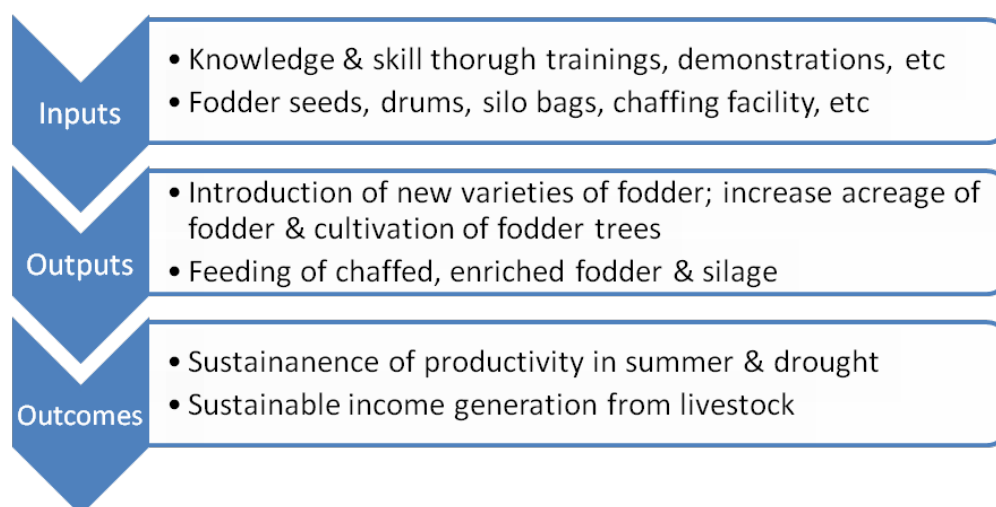
livestock sector. Demonstration of conserving and enriching fodder using silo-bags in Sujala III project in watershed areas of Karnataka have shown that high capacity chaffing machines, preferably above 5HP, diesel operated or tractor driven and wheel mounted are useful. For this to happen various options are available.

1. Promoting young entrepreneurs to own such chaff cutters, use for themselves and rent for others. Two farmers in Gadag district and one in Chamarajanagar district have started providing services for chaffing fodder on hourly basis.
2. Make the right machines available in farm equipment rental yards run by Govt. of Karnataka.
3. Promote Milk Producers' Co-operative Societies or PRIs to own and operate such machines for the benefit of their members.

Stakeholders and their roles: Adoption of any technologies is dependent on various factors such as inherent strength of the technologies themselves, their ease in adoption, availability of inputs, availability of technical knowhow, etc. In this context the various stakeholders involved in the process of development should be involved, empowered and they should perform their roles effectively.

Sl. No	Stakeholder	Role
1.	Farmer	Gain knowledge and skill about the technologies Procure inputs, adopt and use the technologies
2.	MPCS & KMF	Facilitate in chaffing & supply of inputs Arrange for trainings and demonstrations
3.	Dept. of AH&VS	Facilitate in supply of inputs Arrange for trainings and demonstrations
4.	Farmer Entrepreneurs	Facilitate in chaffing of fodder on rent basis Facilitate in silage preparation on payment of service charge basis
5.	Input agencies	Facilitate in supply of inputs like seeds, silo bags, drums, etc
6.	Sujala project (KVAFSU)	Conduct demonstration in all villages with more Outreach programmes Facilitate in training other stakeholders Publicize the technologies using print, electronic, ICT media on a campaign mode.

Outcome of the project: The concept to be implemented requires various inputs. The outputs and outcome of the project if successfully implemented would definitely take livestock management practices to a higher level and contribute to the sustainability of the livestock farming.



Scope for further participatory research: The situations are diverse for the Farmer not to adopt could. Providing a menu of options would help them to choose the best one suiting them. In this context though silage making, dry fodder enrichment, fodder tree usage are all old technologies only how they are presented to the farmers would matter. In this context few areas can be further researched to broad base the menu for the farmers.

Use of cement rings and other commercial available storing & building materials for silage making can be tried out and standardized.

Storage of dry fodder is one critical issue. Stacking is time tested traditional technology farmers practice everywhere. Once, chaffed it need to be protected from rain. Hence, the issue of storage of chaffed dry fodder needs to addressed.

Promoting of young farmers' groups on entrepreneurial mode in silage making on payment of service charges can be thought of.

4.1 Innovative Measures implemented under MGNREGS for Drought Management

Department of Rural Development and Panchayath Raj

Government of Karnataka

Drought like situation is prevailing in most of the Taluks except in the coastal and malnad areas of the State. Due to deficit of rainfall, depleted ground water level due to over exploitation for agricultural and drinking could not cater to the requirement of the demand as a result of which dry atmosphere has been intensified.

Due to the increase of dry atmosphere due to prevailing drought, rural people are facing hardship for their livelihood. With a view to mitigate this situation and also to expand and to make agriculture sector more remunerative, it was felt to implement the Natural Resource Management (NRM) works in both public and private lands. Taking into the stock of the situation it was proposed to select the works from the permissible list of 155 works under MGNREGS, out of which 101 are NRM based works, and of which 11 works have been prioritised and taken up for implementation at Village/GP level and some are being implemented under CM's 21 point programme by the State Government.

In order to mitigate the drought situation in the state, during 2014-15 to 2017-18 Bore well Recharge structures for rural drinking water, multi arch check dams to check the flow of over run of rain water for percolation, and the structures of river rejuvenation are implemented. Now The State Government has accorded priority to implement these innovative programmes under MGNREGS.

In order to mitigate the scarcity of drinking water in rural areas, minimum of 10 Bore well recharge structures are constructed through which rain water can be percolated and increase the water table and this would indeed help in reduction of the magnitude of the Bore Wells being dried up. So far 38307 Bore well recharge structures for drinking water are constructed and commissioned

At GP level to arrest naturally the water being flown in small tanks, katta's and to increase the ground water table and also to check the run of rain water, Multi arch check

dams are being constructed. These dams are innovative and quite contrast from other check dams and also durable. Hence so for 3000 Multi arch check dams are constructed.

With a view to percolate the running water gradually in the watershed areas of the rivers, scientifically modelled rejuvenated works are taken up under MGNREGS. Hence under river rejuvenation programme in Vedavathi, Palar and Kumdavathi river innovative works such as Boulder Check, Recharge Well, Injunction Well and Water ponds are constructed in river watershed areas. The object of this project is to increase the ground water table.

In order to protect moisture in the soil and also for sustainability of growing saplings in summer, it is very much essential to have ponds for storage of rain water in the field. With a view to minimise the deficit of the moisture in the soil over 40000 Farm Ponds are constructed under MGNREGS.

Considering the fertility of the land and to encourage sericulture being the cash crop, provision is made to take up the ultra model of the tree plantation by farmers. Under this programme, sericulture has been developed in 15730 acres. Adding to this, remunerative horticulture crops have also been encouraged in 41885 acres. Emphasis is also been given for the development of the forest in both the waste lands of public and private. Roadside plantation is done in rural area to the extent of 6077 Km so far.

So far 263 vented dams are constructed in Dakshina Kannada District. This is done with a view to use water for agricultural and other allied activities during summer in coastal areas.

4.2 Drinking Water Supply Monitoring System-Web Application implemented in Uttara Kannada District.

S. S. Nakul, IAS

Deputy Commissioner, Uttara Kannada District, Karnataka

Water scarcity is the most visible adverse impact of the drought. It is said that “Water is the elixir of life,” thus water resource management during drought is one of the most critical aspect. Provision of water and equitable access to drinking water are the most important yardstick for judging the effectiveness of drought mitigation measure during drought.

Typically drinking water crisis in urban/rural areas are addressed by drilling new borewells, hydrofracturing of defunct borewells, temporary pipe line extension and transportation of drinking water through tankers/bullock carts etc. However, drilling of new borewells and hydrofracturing are often inefficient and may be unnecessary due to drastic depletion of ground water as a result of consecutive drought especially in Karnataka. Invariably, transportation of drinking water through tankers is the most viable and effective option. But effective monitoring and equitable distribution of drinking water has remained a challenge for administrators.

Often the drinking water supply is riddled with high amount of discretion at the cutting edge level leading to inefficient distribution. Transportation of drinking water has been major source for rent seeking and illegitimate commissioning. The aforementioned reasons have deprived the drinking water during drought to the most vulnerable population and absence of grievance redressal mechanism has aggravated this problem.

Uttara Kannada district is one of the biggest districts in terms of geographical area in Karnataka. The district falls under hilly agroclimatic zone. The major part of the district is covered by hilly areas belonging to Sahyadri hill ranges (Western Ghats) and narrow coastal strip on western side and plain tableland areas on the eastern most parts of the district occupying parts of Mundgod and Haliyal taluks. On an average the district receives annual rainfall of about 2750 mm with very high special variability across the

district, ie, the rainfall decreases from over 3270 mm in the western side (coastal area) to less than 1207 mm in the eastern parts (Mundgod and Haliyal). Mundgod and Haliyal are often drought prone due to erratic rainfall pattern. Villages in these two taluks often face drinking water crisis during summer months. The drinking water is supplied to tanker to villages/hamlets acute drinking water crisis. The aforementioned problems plague effective monitoring and distribution of drinking water. To overcome the same drawback a simple web application called “Drinking Water Supply Monitoring System (DWSMS)” was developed by the district administration. A control room with toll free number and dedicated Whatsapp number has been setup to receive drinking water problem from the general public. The grievance is forwarded to the concerned Tasildhar/Officer, after validating the complaint by taking ground report decision is taken to supply drinking water through tanker. Upon supply of drinking water, the information mentioned in figure 1 is entered in DWSMS.

Figure 2 User Interface for supply of drinking water to new Hamlet in DWDS

The following details are entered in DWSMS

Sl. No.	Description	
1	Taluk	ತಾಲ್ಲೂಕು
2	Gram Panchayat	ಗ್ರಾಮ ಪಂಚಾಯತಿ
3	Date of Water Supply	ದಿನಾಂಕ
4	Village	ಗ್ರಾಮ
5	Hamlet	ಮಜರೆ
6	Number of family for whom water is supplied	ನೀರು ಸರಬರಾಜು ಮಾಡಲಾದ ಒಟ್ಟು ಕುಟುಂಬಗಳ ಸಂಖ್ಯೆ
7	Total Population for which water is supplied	ನೀರು ಸರಬರಾಜು ಮಾಡಲಾದ ಒಟ್ಟು ಜನಸಂಖ್ಯೆ
8	Quantity of water supplied (Litre)	ಸರಬರಾಜು ಮಾಡಲಾದ ನೀರಿನ ಪ್ರಮಾಣ
9	Expenditure for this hamlet only	ಒಟ್ಟು ವೆಚ್ಚ (ಮಜರೆವಾರು)
10	Number of Tankers supplied	ನೀರು ಸರಬರಾಜು ಮಾಡಿದ ಒಟ್ಟು ಟ್ಯಾಂಕರ್‌ಗಳ ಸಂಖ್ಯೆ
11	Tanker registration No.	ನೀರು ಸರಬರಾಜು ಮಾಡಿದ ಟ್ಯಾಂಕರಿನ ರಿಜಿಸ್ಟ್ರೇಷನ್ ಸಂಖ್ಯೆ
12	Tanker Capacity (Litre)	ಟ್ಯಾಂಕರಿನಲ್ಲಿ ನೀರಿನ ಸಾಮರ್ಥ್ಯ

After the data entry is completed, the Tasildhar approves the same for payment. The payment details as in figure 2 are entered.

PAYMENT DETAILS ENTRY					
Month : 1					
Year : 2017					
Select the records for which payment is made and enter the details below					
	GP	Village	Hamlet	Supply Date	Expenditure
☐	KIRAVATTI	HOSALLI	GAONTHANA	31/01/2017	2135
(A) Expenditure Total of above selection		0			
1. Contractor Name *		Select			
2. Amount Paid *					
3. Payment Ref. Number / Cheque Number *				4. Payment Date *	
5. Payment Order Number & Date *					
6. Scanned Cheque & Acknowledgment *		Choose file No file chosen (Make a SINGLE PDF of Cheque & Acknowledgement, and Upload here. Only PDF files are supported. File size must not exceed 3.5MB. To reduce the PDF file size, scan the pages in Grayscale mode.)			

Figure 3 User interface for filling payment details

Once this is entered, the number of trips is clicked, the system auto calculates the amount to be paid and contractor details are selected from the drop down list. The Tasildhar approves the amount by submitting the submit button. The payment is directly credited to the Contractor's account through NEFT. The graphical interface for the same is given in figure 3 and 4.

☐	KIRAVATTI	HOSALLI	GAONTHANA	20/02/2017	2135
☐	KIRAVATTI	HOSALLI	GAONTHANA	21/02/2017	2135
☐	KIRAVATTI	HOSALLI	GAONTHANA	22/02/2017	2135
☐	KIRAVATTI	HOSALLI	GAONTHANA	23/02/2017	2135
☐	KIRAVATTI	HOSALLI	GAONTHANA	24/02/2017	2135
☐	KIRAVATTI	HOSALLI	GAONTHANA	25/02/2017	2135
☐	KIRAVATTI	HOSALLI	GAONTHANA	26/02/2017	2135
☒	KIRAVATTI	HOSALLI	GAONTHANA	27/02/2017	2135
☒	KIRAVATTI	HOSALLI	GAONTHANA	28/02/2017	2135

(A) Expenditure Total of above selection 4270

1. Contractor Name * Select

2. Amount Paid *

3. Payment Ref. Number / Cheque Number *

4. Payment Date *

Figure 4: Payment interface

☐	KIRAVATTI	HOSALLI	GAONTHANA	26/02/2017	2135
☒	KIRAVATTI	HOSALLI	GAONTHANA	27/02/2017	2135
☒	KIRAVATTI	HOSALLI	GAONTHANA	28/02/2017	2135

(A) Expenditure Total of above selection 4270

1. Contractor Name * Select

2. Amount Paid * Select

3. Payment Ref. Number / Cheque Number *

4. Payment Date *

5. Payment Order Number & Date *

6. Scanned Cheque & Acknowledgment *

Choose file No file chosen

(Make a SINGLE PDF of Cheque & Acknowledgement, and Upload here. Only PDF files are supported. File siz 3.5MB. To reduce the PDF file size, scan the pages in Grayscale mode.)

SUBMIT

Figure 5: Payment interface

Advantages of DWSMS:

1. Communities are empowered by **easy grievance redressal mechanism** through Whatsapp and toll free number to lodge drinking water related complain.
2. **Equitable Distribution:** Vulnerable community in remote hamlets are not deprived of drinking water during drinking water crisis.

3. **Transparency:** Each stage of water supply process validated at various levels and communities.
4. **On time payment:** Contractors who supply drinking water paid directly to the bank account and need not approach any officers for payment, which invariably cuts down on commission/rent seeking.
5. **Enables to build water requirement database:** The exact quantity of water supplied is readily available to district administration through DWSMS, which enable the blocks to calculate water demand and supply. This data can be used to **plan long term structural intervention** such as water recharging structures, check damages, ponds etc.
- **Administration convenience:** Earlier, the drinking water supply process used to consume significant time and administrative resources (Revenue machinery) in the taluk and district level to monitor the supply. Post implementation of DWSWS, routine drudgery of manual monitoring is dispensed with.

Finally, this simple intervention has had a very significant impact in **effective and equitable transportation of drinking water** to most vulnerable hamlets in Uttara Kannada district.

4.3 Necessary measures for drought and to provide safe drinking water to rural habitations in Karnataka

Chief Engineer

Rural Drinking Water Supply & Sanitation Department, Bangalore

The State Government is continuously extending support to provide safe drinking water for rural habitations through Multi village water supply, Piped water supply, Mini water supply and Hand pump schemes. The priority of the Government is to provide safe drinking water, for which water purification plants are being provided to give immediate relief to all the quality affected and thier habitations with ground water source.

Due to consecutive drought situation in the state, to mitigate the water scarcity for drinking, agriculture and catchment areas of reservoirs, cloud seeding operation was taken up during the monsoon period of 2017. The cloud seeding was taken up to bring down the water scarcity in the reservoir catchment area and the regions of very low precipitation.

Government has set up priority for providing safe drinking water in all 60,248 rural habitation in Karnataka through newly setup RDW&SD. The Government has enhanced the supply from 55 LPCD to 85 LPCD so that the lifestyle of the rural population is enhanced.

In Karnataka so for 2,24,735 Hand pump schemes, 50,499 Mini water supply schemes and 37,592 Piped water supply schemes have been implemented.

Multi Village Water Supply Schemes

Due to over exploitation of Ground Water and intervention of chemical pollutants like Fluoride, TDS, Nitrates, Iron and other parameters, the contaminated of drinking water has been increasing from day to day. To minimize dependency on ground water sources, Government is supporting surface water schemes on priority.

In Karnataka more than 400 MVS schemes have been implemented benefitting nearly a crore of rural population. These schemes provide safe drinking water supply through the surface water sources.

In addition to the above, 135 MVS schemes are under progress which will benefit nearly 1.5 crore rural population. With this the healthy of rural population is being improved, which in turn helps the economical growth of rural areas.

Water Purification Plants:

The surface water schemes are taken up as a long term planning to provide immediate relief through safe drinking water of portable quality. The Government has taken a big step and 10,353 WPP are established, this has benefitted about 1.6 crore rural population in mitigating the health hazards of contaminated water. During the present year another 3000 WPPs are being provided in rural areas benefitting about 20 lakhs population.

Karnataka Cloud Seeding Operations (VarshaDhare – 2017)

Government of Karnataka has taken up Aerial Cloud Seeding Operation-2017 due to consecutive 3 year drought situation and due to the delay in the onset of the monsoon. It had become very difficult for the people to get drinking water because of drying up of borewell sources.

The cloud seeding operation has been conducted in order to enhance precipitation to deal with drought situation and water shortage in arable and non-arable areas, to raise the water level in the reservoirs and to improve precipitation in low rain fall receiving regions of Karnataka. This is a crucial project for predominantly rain dependent farmers of Karnataka.

The programme is conducted from 23rd August 2017 to 10th November 2017 with 2 advanced scientific Aircrafts. The seeding operation were carried out on 55 days considering the suitable environment and convection of seedable clouds. A total of 1302 flares have been used with in 287 hours of flying from both aircrafts.

The cloud seeding operations is found to be useful in most part of the Karnataka as opined by the technical experts. The cloud seeding programme is found to be successful over the state. Technical Evaluation Committee is reviewing the report submitted by the contractors and the recommendation of the committee is awaited.

5.1 Karnataka Fodder Security Policy- 2018

Animal Husbandry and Veterinary Science

Government of Karnataka

Executive Summary:

Livestock sector has provided large self employment opportunities and supported livelihood of millions of households. The annual milk and meat production have been increasing year after year. But, the state of Karnataka is facing a major challenge of shortage of fodder there by hindering fullest expression of genetic potential of the existing livestock. Annually, 85 million tonnes of green fodder and 15 million tonnes of dry fodder are available against the requirement of 122 million tonnes of green and 25.40 million tonnes of dry fodder respectively. Frequent occurrence of drought has caused wide spread hardships in providing fodder to the livestock. Hence, fodder varieties, intensive fodder production through rejuvenation of grass lands, silvi pasture, expansion of area under fodder crops, advanced methods of processing and storage. Capacity building and incentives for the stakeholders and role of various institutions or agencies in achieving the objectives of the policy have been delineated.

1. Sustainable Livestock Production with ensured fodder security in light of consecutive droughts

1.1 Background

In India, the livestock sector has provided large self-employment opportunities and supported livelihood of millions of people. Over the last three decades, a considerable increase in major livestock products has been recorded. The contribution of livestock to GDP at current prices showed a steady increase from 3.94% in 2010-11 to 4.40 % during 2014-15 which is 26.90 per cent of Agriculture GDP.

The annual milk production has seen a sea change that it increased from 121.80 million tonnes in 2010-11 to 146.30 million tonnes in 2014-15. Per capita availability of

milk also increased considerably from 281 grams (2010-11) to 310 grams (2014-15). Annual meat production increased from 4.90 million tonnes to 6.70 million tonnes.

The livestock sector in Karnataka is contributing 4.41% to GSDP and 21.83% of income from agriculture and allied sector. The growth rate is qualitatively superior in animal husbandry sector. There is a shift in the demand for protein products especially from animal protein. Although the growth rate in number of animals is at minimum there is considerable growth in the productivity of the livestock.

In milk as well as meat production the state stands at 11th place at national level. The milk and meat productions have increased year after year. The annual milk production which was 5.11 million tons in 2010-11 increased to 6.12 million tons in 2014-15. The meat production increased from 123910 tons to 181312 tons during the same period. The per capita availability of milk increased from 237gram in 2010-11 to 276grams in 2014-15.

But, since decades, the state is facing a major challenge of shortage of fodder, more so during drought and summer. In spite of excellent genetic potential in the livestock for production, availability of fodder both in quantity and quality has become a hurdle in achieving the expected production. Improved health care facilities are available. But, non-availability of sufficient and good quality fodder has resulted in low average production per animal.

Annually from all sources 85 million tonnes of green fodder is available against the requirement of 122 million tonnes indicating a deficit of 30 per cent. Similarly, 15 million tonnes of dry fodder is available against the demand of 25.4 million tonnes showing a shortfall of 40.90 per cent (Kammardi et.al. 2017).

1.2 State Level Scenario

Karnataka has 2.9 crore of livestock (as per the 19th Livestock Census 2012). The economic survey of Karnataka (2015-16) states that Karnataka livestock sector plays an important role in improving the economic status of the rural farmers who are dependent on the livestock for their livelihood.

The state has been facing shortage of fodder, more so during drought and summer. Improved health care facilities are available. But, non-availability of sufficient and good quality fodder has resulted in low average production per animal.

1.3 Drought in Karnataka

The occurrence of droughts in Karnataka state is a common phenomenon, due to spatial and temporal variation in rainfall which ranges from 5051 mm in coastal region, followed by Malnad region with 3500mm to as low as 508mm in south interior Karnataka. There is both temporal and spatial variability within the region. Besides, there is temporal variability between and within the seasons. Due to this variability both spatially and temporally different regions are prone to disasters like floods and droughts simultaneously in the State. The State is regularly affected by drought and it covers almost the entire rain-fed agricultural area. Nearly 80% of these taluks in the State are drought prone (KSNDMC, 2018)

Out of the total 19.1 M Ha in Karnataka the net cultivated area (2010-11) was 10.5 M Ha, net irrigated area 3.49 M Ha and net rain fed cultivated area 7.01 M Ha. Karnataka has the second largest area under rain-fed agriculture after Rajasthan in the country (Drought Vulnerability of Karnataka, (KSNDMC, 2018).

Droughts have occurred in 13 years in Karnataka in the last 16 years. The year-wise number of Taluks affected by drought in Karnataka from 2001-2016 are enlisted (Drought Vulnerability Assessment in Karnataka, KSNDMC, 2018).

2. Need for a Fodder Policy

In the light of consecutive droughts and reduction in grazing lands, there is imminent fodder scarcity due to reduction in crop residue availability and shortage of fodder. This requires an appropriate comprehensive strategy to address the issues of fodder security, better utilization of agri-residues and encouraging Public Private Partnership (PPP) in fodder production.

It is predicted that meat and milk consumption will grow at 2.8 and 3.3% per annum, respectively in India (IGFRI Vision 2030). Livestock population is expected to grow at the rate of 1.23% in the coming years. There is tremendous pressure of livestock on available total feed and fodder, as consecutive droughts and land availability for fodder production has been decreasing. Therefore, fodder based low cost feeding strategies are required to reduce cost of quality livestock product as feed alone constitutes 70% of the milk production cost.

There is also a need to develop high yielding varieties with enhanced palatability and other quality traits, adaptability to different agro ecological zones, suitability to diverse farming situations and improved production techniques. Demonstration of these techniques in the field condition is needed to achieve desired performance among livestock productivity. Climate change induces stress (extreme events such as drought, high intensity rainfall, hailstorm etc) are likely to impact fodder production. Adapting to climate change is expected to be an important issue for fodder security.

2.1 Challenges of Fodder Development

- a) Size of Land holdings:** As majority of dairy farmers are marginal and own small holdings for cultivation. Their priority is to produce food grains. Organized fodder cultivation on commercial lines is insignificant. It is estimated that only 4.4% of the total cropped area is devoted to fodder production.
- b) Reduction of grazing lands:** Gradual transformation of agricultural lands for real estate due to urbanization has been the prime reason for reduction of grazing lands. As a result, many organized dairy farmers are forced to move towards zero grazing system of feeding, while the small and marginal dairy farmers are left with no option to get rid of animals.
- c) Lack of preservation practices:** Shortage of fodder is ordinarily observed during every summer which is more conspicuous in the drought conditions. Except preservation of crop residues in the form of stalks at farmer level, the other preservation practices in the form of silage bales, fodder blocks, etc., are nearly absent

among farmers mainly due to lack of awareness about preservation techniques. Most of the crop residues are stored as dry fodder in the form of stalks.

- d) Logistics Involved in Fodder Transportation:** Due to wide gap between fodder availability and requirement within each district, the transportation of fodder from one district to another is a major challenge because of the cost factor involved.

2.2 Livestock-a hedge against inimical impacts of drought

Livestock is the mainstay and wealth of the rural economy. As small and marginal farmers constitute about 80% of the total community of farmers in the country for whom, livestock often is a valuable asset to supplement income from their small landholdings. Livestock ownership diversifies production and resource management options, increases total farm production and income, provides year-round employment and spread risk. Studies have shown that the more Livestock a farmer owns, the less vulnerable the farmer is to risks (Manual for Drought Management ,2016). During a drought situation, every measure needs to be taken to save livestock from mortality or distress sale by ensuring fodder security, drinking water and medicines.

2.3 Fodder Policy objectives:

1. Development of high yielding varieties with desired quality parameters in different forage crops.
2. Identification of sustainable and remunerative forage based cropping system.
3. Intensive forage production through grass legume mixtures.
4. Intensive forage production through silvi- horti pasture system.
5. Dissemination of scientific information to the extension personnel and through technology demonstration and training.
6. Supply of seeds and planting material and technical knowhow to the farming community.
7. Quality fodder seed production of improved varieties.

2.4. Policy Vision

To produce requisite fodder in Karnataka state for the next 5 years by propagating improved fodder varieties, to obtain maximum production from livestock and develop and popularize farmer friendly technologies (Enrichment of crop residues, forage blocks and preparation of silage and hay)

2.5 Policy Mission

- a) To ensure availability of fodder during all seasons
- b) Introduction of need based fodder technology for preservation of fodder
- c) Creation of storage facilities – fodder bank among the farming community
- d) Application of proper post-harvest technologies for optimal utilization of crop residues in the state
- e) Introduction of hydroponic fodder production units.
- f) Promotion of fodder trees
- g) Development of pasture lands

2.6 Policy Validity

The Policy has been framed for the period 2018-2023.

3.0 Availability of crop residues in Karnataka

Sl.No	Crops	Crop residues (Lakh Tonnes)
1	Ragi	20.74
2	Sugarcane	3.60
3	Maize	78.28
4	Paddy	44.40
5	Field bean	0.45
6	Horse gram	3.5
7	Mulberry	1.60

In order to meet the demand (172.9 Mt) approximately 5.09 lakh ha of area need to be covered under fodder cultivation

3 Opportunities for Fodder Development

- a) **Silage as green fodder:** Maize corn silage has 9% protein. If it is packed and preserved in bales, it can offer solution for yearlong supply of high quality green fodder irrespective of season.
- b) **Straw Stalks:** Paddy straw is burnt in coastal districts after machine harvesting as collection of straw manually is not cost effective. The straw that gets wasted can be otherwise best collected and processed into bales which can be transported and stored at strategic locations in deficit areas for use as and when required.
- c) **Hay:** Promotion of protein rich fodders such as Alfalfa during winter season and stored in its dry form as blocks can offer a solution to reduce concentrate feed in the ration.
- d) **Ration Balancing Program (RBP):** The RBP available with NDDDB under National Dairy Plan (NDP) can also offer excellent solution for formulation of balanced ration to the livestock based on the locally available resources with the farmers. This will help to reduce the cost of production.
- e) **Total Mixed Ration:** The practice of mixing green fodder or silage with dry fodder and concentrates along with all other nutrients enables a complete ration that increases digestibility and enable utilization of nutrients at optimum level.
- f) **Augmenting forage production:** Augmenting forage production under prevalent cropping system can be brought under following systems of forage production systems:
 - 1. Irrigated ecosystem: cultivation of perennial grasses like Bajra Napier hybrid, Guinea grass and para grasses on rice field bunds
 - 2. Introduction of short duration forage crops under limited water available situation (Maize and Millets)
 - 3. Utilization of marshy areas for fodder production with suitable perennial grasses like Paragrass, Azolla etc.

4. Cultivation of forages in the waste land
5. Cultivation of fodder trees on farm bunds
6. Agro forestry systems including Silvi pasture with fodder trees like Acacia, Halavana, Glirissidia, Sesbania, Subabul etc along with perennial pasture grass varieties.
7. Problematic soils like alkali soils for cultivation of Congo signal and green panic grass
8. Preservation and storage adopting suitable methods and storage at strategic points in drought prone areas.

4. Land Use Pattern in Karnataka

District-Wise Demand and Supply of Fodder (Crop Residues) Production in Karnataka

A study was undertaken by Veterinary Collage, Hebbal, Bengaluru, to assess the present demand and supply of fodder production in different districts of Karnataka and also to identify the districts with high vulnerability for fodder shortage based on their rainfall pattern. The secondary data was collected from the Animal Husbandry and Veterinary Department, Bengaluru and Natural disaster monitoring centre, Government of Karnataka. The results revealed that Kolar, Mandya, Bidar, Yadgir, Chikmagalur, Dakshina Kannada, Udupi and Uttara Kannada were considered as highly vulnerable districts whereas Bengaluru urban, Ramanagara, Chikkaballapur, Tumkur, Belgaum, Gulbarga, Dharwad, Bagalkote and Shivamogga come under moderate vulnerability category towards fodder shortfall. The remaining districts like Bengaluru rural, Chitradurga, Mysore, Bellary, Chamrajnagar, Davanagere, Bijapur, Raichur, Gadag, Haveri, Koppal, Hassan and Kodagu have less vulnerability of fodder deficit and also act as surplus districts to fulfil the fodder requirement of other deficit districts of Karnataka (Kamardi, S., Shilpashree, J., Vankayala, J., & Achoth, L. 2017)).

5. Proposed Initiatives to Enhance Fodder Production Stakeholders

The Livestock farmers, the Government institutions, District Milk Unions, Farm Universities and fodder processing enterprises are the main stakeholders.

6. Fiscal Incentives

Sl. No	Particulars	Incentive
1	Green fodder growing	Input subsidy limited to the cost of seeds and fertilizers, Max. Rs. 4000 per Ha.
2	Perennial Grass cultivation	Cost of Root slips and fertilizers Max. Rs.2000 per Ha.
3	Silage Production unit	Rs. 1.00 lakh or 50 per cent of non-recurring investment
4	Chaffed Dry fodder Unit	power operated Chaff cutter at 50 per cent subsidy
5	Azolla cultivation	Rs. 2000 per unit of 8' X 4' size
6	Fodder block Making unit	50 per cent of the Machinery cost Max. Rs. 1.00 lakh
7	Fodder baling unit	Max. Rs 2.00 lakhs towards machinery cost
8	Hydroponic Fodder units	50 per cent of Non-recurring Expenditure
9	Best Fodder Grower- one per District and one at state level	Rs. 1.00 lakh each
10	Best Fodder Entrepreneur - state level	Rs. 2.00 lakhs

5.2 A Success Story of Fodder Management during Drought - Kolar Model

Department of Animal Husbandry and Veterinary Science

Kolar District, Karnataka

Introduction

Kolar district has been severely affected by drought continuously for the past three years. Farmers of Kolar district are mainly dependent on Animal Husbandry, Horticulture and Sericulture activities for their livelihood. Normal rainfall of the district is 622 mm but actual rainfall in the year 2016 is 418 mm. The district has 276195 cattle and buffaloes population. The main crops grown are Ragi and Jowar. The residues of these crops are being used as fodder. Due to continuous drought since the past three years, Animal Husbandry activities suffered a lot due to severe shortage of fodder. In order to overcome this situation the district administration, Zilla panchayath, Dept of AH&VS and Milk Union Kolar took an initiative to grow green fodder in the farmers field by way of “**Participatory Fodder Production Programme**” under the guidance of Deputy Commissioner Kolar District.

Methodology adopted

Under this programme the members of MPCS (Milk producers co-operative Society) who showed interest to grow green fodder instead of other crops in their field were identified in each Village. Those who possessed tubewell / bore well and were willing to participate in this program were assured that the Fodder grown by them will be purchased by M.P.C.S of that village at the prevailing market price. A Co-Ordination Committee comprising of department of Animal Husbandry, Milk Union (K.M.F) and all other line departments was formed and village wise action plan was prepared (**Annexure-1**). The Farmers were encouraged to grow fodder on their own fields, for which the following facilities were provided by the district administration.

Facilities:

- Farmers were assured of market price with an agreement with M.P.C.S of that village.
- Fodder seeds were supplied free of cost by the Government through the department of Animal Husbandry in a phased manner so that green fodder would be available throughout the season.
- An incentive of Rs.3000/-per acre of fodder grown was given to the farmers by Kolar Milk Union.
- In the villages where M.P.C.S were not existing concerned Gram Panchayath officer and local Veterinary officer were asked to enter into an agreement with the Farmers.

As per the cattle population of Kolar district, fodder required for sixty days was calculated considering 15 kg per day per animal totaling to 2.48 lakh tonnes of for which 16574 acres of land was required. As per the base line survey, the farmers had already sown fodder in 6680 acres of land. Further, additional 8465 acres was identified totaling up to an area of 15145 acres in which 2.27 lakh tonnes of fodder was produced. **(Annexure-2)**. Later on 2603 acres of land was brought under for fodder production additionally achieving a goal of growing fodder in 17,748 acres of Land.

Between November 2016 and May 2017, Animal Husbandry Department has distributed 65,287 A.T.M fodder seeds and 24,321 S.S.G fodder seed minikits and Milk Union 5,675 A.T.M minikits and 14,796 S.S.G minikits free of cost to the farmers in a phased manner to make green fodder available to the animal during distress season thus making the dairy farmer economically stable.

District nodal officers had been appointed by the Deputy Commissioner to monitor the progress in each hobli made under this programme. Fodder management app was created exclusively to get the information regarding fodder production and was reviewed by DC on weekly basis.

Results and Discussion

The green fodder grown under this program was sold to the needy farmers engaged in dairy activities through MPCs at a price of Rs.2500 per tonne. The farmers were

coming forward voluntarily to grow fodder as a commercial crop and have gained considerable profit.

Under this program green fodder was made available to the farmers even in severe drought condition thereby enhancing the milk production of individual animals by 2-3 ltrs and increasing the average procurement of milk by 4% (**Annexure-3**). By giving green fodder the desired quality of milk i.e 8.5% of SNF and 3.5% of fat was achieved. In addition GOK paid an incentive of Rs 5/- ltr of quality milk production to the farmers. Due to availability of green fodder under severe drought condition farmers were able to save substantial amount by way of reducing the concentrate feed by 2-3 kgs.

On an average 15 tonnes of green fodder was produced in an acre of land incurring approximately an expenditure of Rs.6000 out of which seeds worth Rs.1000 was given free of cost and the selling price of one tonne of green fodder being Rs.2500, the farmers received Rs.37500 from one acre of land (A profit of Rs.32500).

Due to severe drought situation resulting in fodder scarcity the milk production should have decreased but provision of green fodder during the crisis has substantially increased the milk production.

In comparison to the other districts of the state where Goshalas and fodder banks were established to manage fodder crisis during the same drought, no Goshalas/ fodder banks were being established in Kolar district. Instead of this green fodder was cultivated in the interested farmers land. For establishment and maintenance of a Goshala with capacity of 500 animals for a period of three months, the minimum expenditure would be around Rs.50.00 lakh. But by adopting the methodology of green fodder cultivation savings have been done to the ex-chequer of Govt.

Conclusion

By adopting the methodology of green fodder cultivation the farmers have been benefited, Milk production has not declined even during the distress period and by not establishing Goshala / fodder bank savings have been made to the Govt. ex-chequer.

Annexure-1 (Model Action Plan)
Veterinary Hospital, Mulabagal

As on 26/12/2016

Sl. No	Hobli	Village	Jurisdiction M.P.C.S	Animal Population	Fodder requirment for day	Fodder requirement for 60 day	Land requirement to grow fodder of 60 days requirement	Area sown for fodder production (in acres)			Further Lands to be Identified
								Famer grown on their own	Identified Land during survey	Total	
1	Kasaba	Mulabagal	Town	997	14.955	897.3	59.82	5	7	12	47.82
2	Kasaba	Kadeeripura	Veerupakshi	314	4.71	282.6	18.84	6	0	6	12.84
3	Kasaba	Chikkabandahalli	Chamareddyhalli	140	2.1	126	8.4	5	12	17	0
4	Kasaba	Doddabandahalli	Doddabandahalli	133	1.995	119.7	7.98	6	2.2	8.2	0
5	Kasaba	V. Gangapura	V. Gangapura	233	3495	209.7	13.98	10	2	12	1.98
6	Kasaba	Chamareddyhalli	Chamareddyhalli	247	3705	222.3	14.82	14	2	16	0
7	Kasaba	Sonvadi	Sonvadi	316	4.74	284.4	18.96	6	4.2	10.2	8.76
8	Kasaba	Kavathanahalli	Kavathanahalli	212	3.18	190.8	12.72	7	1.2	8.2	4.52
9	Kasaba	Gumlapura	Gumlapura	126	1.89	113.4	7.56	4	3	7	0.56
10	Kasaba	Chaluvanayakanahalli	Siddaghatta	195	2.925	175.5	11.7	4	0	4	7.7
11	Kasaba	Lingapura	Siddaghatta	407	6.105	366.3	24.42	4	1	5	19.42
12	Kasaba	Segenahalli	Seegenahalli	229	3.435	206.1	13.74	8	1	9	4.74
13	Kasaba	Darenahalli	Marandahalli	46	0.69	41.4	2.76	0.25	0	0.25	2.51
14	Kasaba	Kadripura	Kadripura	252	3.78	226.4	15.12	8	2	10	5.12
15	Kasaba	Piccagundahalli	Piccagundahalli	225	3.375	202.5	13.5	10	6	16	0
16	Kasaba	Kasavireddyhalli	Kasavireddyhalli	145	2.175	130.5	8.7	5	3	8	0.7
17	Kasaba	Lakkashettihalli	Lakkashettihalli	115	1.725	103.5	6.9	8	2.2	10.2	0
18	Kasaba	Yarrajinahalli	Yarrajinahalli	72	1.08	64.8	4.32	4	2	6	0
		Percentage of Growth		4404	7258.86	3963.2	264.24	114.25	50.8	165.1	99.19

Annexure-2

Talukwise Fodder Production

Sl. No	Taluk	Total Livestock	Fodder Required for 60 days (in tonns)	Land Required to grow fodder for 60 days (in acres)	Area sown for fodder production (in acres)		Total (in acres)	Fodder Production (in tonns)
					Farmers Grown on their own	Grown with help of district administration		
1	Malur	34293	30864	2058	925	1133	2058	30870
2	Srinivasapura	56015	50413	3362	1847	1385	3232	48480
3	Mulbagilu	67230	60507	4033	1260	1880	3140	47100
4	Kolar	58934	53041	3536	1498	3179	4677	70155
5	Bangarpet	59723	53750	3585	1150	888	2038	30570
Total		276195	248575	16574	6680	8465	15145	227175

ANNEXURE – 3

Kolar Disrtict Co-Operative Milk Producers Societies Union Ltd Kolar

Talukwise procurement Details for the year 2015-16 And 2016-17

Sl.No	Name of the Taluk	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	Avg proc of 6 Months
1	KOLAR	136396	126228	125565	125728	121907	118444	117246	124552
2	BANGARPET	92209	85685	85673	87009	84735	85171	85025	86528
3	MULBAGAL	89421	79100	77670	77292	74369	75462	79108	78958
4	MALUR	94683	87538	87510	87289	83869	82117	81383	86382
5	SRINIVASAPUR	72935	66126	65355	66290	63257	62265	62353	65545
	Total	485644	444677	441773	443608	428137	423459	425115	441965

Sl.No	Name of the Taluk	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	Avg proc of 6 Months
1	KOLAR	135454	131278	125814	130687	124152	121307	120491	127064
2	BANGARPET	98253	94392	88714	90707	86515	85793	85684	90041
3	MULBAGAL	96397	90087	83625	86353	82373	82307	82525	86274
4	MALUR	100164	98270	90086	89986	84718	84109	84467	90299
5	SRINIVASAPUR	73684	69658	65295	67420	63170	61760	63135	66332
	Total	503952	483685	453534	465153	440928	435276	436302	460010
Percentage of growth		3.77	8.77	2.66	4.86	2.99	2.79	2.63	4.08

6.1 Drought Mitigation Programmes

Department of Horticulture

Government of Karnataka

A drought is a period of below-average precipitation resulting in prolonged shortages in the water supply, whether atmospheric, surface water or ground water. A drought can last for months or years, or may be declared after as few as 15 days.

It can have a substantial impact on the ecosystem and agriculture of the affected region and harm to the local economy. Annual dry seasons in the tropics significantly increase the chances of a drought developing and subsequent bush fires. Periods of heat can significantly worsen drought conditions by hastening evaporation of water .

Aberrant monsoon may lead to moisture deficit which may affect the horticultural crops.

Types:

As a drought persists, the conditions surrounding it gradually worsen and its impact on the local population gradually increases. People tend to define droughts in three main ways.

1. **Meteorological drought** is brought about when there is a prolonged time with less than average precipitation. Meteorological drought usually precedes the other kinds of drought.
2. **Agricultural droughts** affect crop production or the ecology of the range. This condition can also arise independently from any change in precipitation levels when soil conditions and erosion triggered by poorly planned agricultural endeavors cause a shortfall in water available to the crops. However, in a traditional drought, it is caused by an extended period of below average precipitation.

3. **Hydrological drought** is brought about when the water reserves available in sources such as aquifers, lakes and reservoirs fall below the statistical average.

Common Consequences of drought

- **Environmental effects:** increased pollution of surface water, the drying out of wetlands, more and larger fires, higher deflation intensity, loss of biodiversity, worse health of trees and the appearance of pests and dendroid diseases.
- **Economic losses:** lower agricultural, forests, game and fishing output, higher food-production costs, lower energy-production levels in hydro plants, losses caused by depleted water tourism and transport revenue, problems with water supply for the energy sector disruption of water supplies for municipal economies.
- **Social costs:** the negative effect on the health of people directly exposed to this phenomenon (excessive heat waves), possible limitation of water supplies, increased pollution levels, high food-costs, stress caused by failed harvests, etc.
- Drought can also reduce water quality, because lower water-flows reduce dilution of pollutants and increase contamination of remaining water-sources.
- Diminished crop growth or yield productions and carrying capacity for livestock
- Dust bowls, themselves a sign of erosion, which further erode the landscape
- Dust storms, when drought hits an area suffering from desertification and erosion
- Famine due to lack of water for irrigation
- Habitat damage, affecting both terrestrial and aquatic wildlife.
- Hunger - drought provides too little water to support food crops.
- Malnutrition, dehydration and related diseases
- Mass migration, resulting in internal displacement and international refugees
- Reduced electricity production due to reduced water-flow through hydroelectric dams.
- Shortages of water for industrial users.

- Snake migration, which results in snake-bites.
- Social unrest
- War over natural resources, including water and food
- Wildfires, such as Australian bushfires, become more common during times of drought and may cause human deaths.
- Exposure and oxidation of acid sulfate soils due to falling surface- and ground-water levels.
- Cyanotoxin accumulation within food chains and water supply (some of which are among the most potent toxins known to science) can cause cancer with low exposure over the long term.

Strategies for drought protection, mitigation or relief : include

- **Dams** - many dams and their associated reservoirs supply additional water in times of drought.
- **Cloud seeding** - a form of intentional weather modification to induce rainfall.
- **Desalination** - of sea water for irrigation or consumption.
- **Drought monitoring** - Continuous observation of rainfall levels and comparisons with current usage levels can help prevent man-made drought.
- **Land use** - Carefully planned crop rotation can help to minimize erosion and allow farmers to plant less water-dependent crops in drier years.
- **Outdoor water-use restriction** - Regulating the use of sprinklers, hoses or buckets on outdoor plants, filling pools, and other water-intensive home maintenance tasks.
- **Rainwater harvesting** - Collection and storage of rainwater from roofs or other suitable catchments.
- **Recycled water** - Former wastewater (sewage) that has been treated and purified for reuse.

- **Transvasement** - Building canals or redirecting rivers as massive attempts at irrigation in drought-prone areas.

Drought mitigation measures in Agriculture and Horticulture:

The objectives of these mitigation measures are to reduce soil erosion, augment soil moisture, restrict surface run-off of rainwater and improve the efficiency of water use. It involves a wide range of soil and water conservation measures and farm practices.

- Water harvesting and conservation – refers to processes and structures of rainfall and run-off collection from large catchments area and channeling them for human consumption.
- Artificial recharge of ground water - A typical water shed development program has several components depending on the topography , nature and depth of soil cover and type of rocks and their pattern of formation and layout , absorbing capacity of land , rainfall intensity and land use. These include the following.
 1. **Contour bunding:** is one of the most widely practiced soil and water conservation measures, which controls erosion, conserves moisture, recharges groundwater and prevents silting of tanks and reservoirs in the downstream.
 2. **Contour Trenching:** This consists of excavating shallow/intermittent trenchers across the land slope and forming a small earthen bund on the downstream side.
 3. **Contour Cultivation:** Contour operations are done across the slope by cultivating crops and trees on the contour.
 4. **Bench Terracing:** Bench terracing is practiced on steep hilly slopes where agriculture has replaced natural forest and grasslands since a long time.
 5. **Graded Bunding and etc.,**
 6. **Farm Ponds:** Farm ponds are an important component and useful in storing water for irrigation etc.,
 7. **Improved water saving farm practices.**

General recommendations

1. Selection of suitable crops and varieties:

In vegetable crops like dolichos bean, cowpea, cluster bean, lima bean, chilli, drumstick, brinjal, okra, Tomato & Onion are suitable for rain-fed cultivation. Among these, legume vegetables can be recommended for contingency crop-planning in an eventuality of late monsoon rains. Varieties having good root system and capacity to recoup after the alleviation of stress need to be selected. Depending upon situation, it is recommended to use short duration varieties.

2. Improved method of seedling production:

Improved method of seedling production such as Portray grown seedling using coco peat, nylon net protection and bio-fertilizers/bio-pesticide inoculation at nursery stage has good potential for obtaining sturdy, uniform and healthy seedlings. These seedlings when transplanted in the main-field will establish better with less root damage and fare better in overcoming biotic and abiotic stresses particularly during water stress conditions.

3. Adoption of soil and moisture conservation techniques:

Contour cultivation, contour trip cropping, mixed Cropping, tillage, mulching, zero tillage, are some of the agronomical measures for the in-situ soil moisture conservation. Mechanical measures like contour bunding, crescent bunding, graded bunding, bench terracing, polythene mulching etc. also need to be followed for effective soil and moisture conservation in dry lands. Another technology for efficient utilization of runoff is water harvesting recycling. Rainwater harvesting includes collecting runoff water into dug out ponds or tanks in small depressions, gullies and into storage dams of earth or masonry structures. Rain water harvesting is possible in areas having rainfall as little as 500 to 800 mm. Depending on the rainfall and soil characteristics, 10-50 % of the runoff can be collected in farm pond. Surface run off thus collected in a farm pond can be used to provide protective irrigation in the period of prolonged dry spell or through microirrigation techniques.

4. Enhancing soil organic matter content:

Constant efforts must be made to improve the soil organic carbon. Incorporation of crop residues and farm yard manure to soil improves the organic matter status, improves soil structure and soil moisture storage capacity. Organic matter content of the soil can also be improved by fallowing alley cropping, green manuring, crop rotation and agro forestry. Vegetable being short duration crop and having faster growth phases, the available organic matter needs to be properly composted. Vermi composting can be followed for quicker usage of available organic matter in the soil and improving the soil moisture holding capacity.

5. Application of foliar nutrition:

The foliar application of nutrients during water stress conditions helps in the better growth by quick absorption of nutrients. The spraying of K and Ca induces drought tolerance in vegetable crops. Spraying of micronutrients and secondary nutrients improves crop yields and quality.

6. Use of drip irrigation:

Drip irrigation has proved its superiority over other conventional method of irrigation, in horticulture due to precise and direct application of water in root zone. A considerable saving in water, increased growth, development and yields of fruits and vegetables and control of weeds, saving in labour under drip irrigation are the added advantages. Drip irrigation can be adopted in fruit crops and also to all vegetable crops including closed spaced crops like onions and beans. The saving in water is to the tune of 30-50 % depending on the crop and season. Generally inline drip laterals having emitting point spaced at 30cm distance and emitting at the rate of 2LPH is selected for vegetable crops. In crops like chilli, brinjal, cauliflower and okra paired row planting is practiced and one drip lateral is used for two crop rows.

7. Use of micro sprinkler irrigation:

Depending upon situation and availability of water, this technology can be used for fruits and vegetable crops. The cost of initial establishment is lower compared to drip system. Further in summer the sprinkling of water helps in reducing the microclimate temperature and increasing the humidity, thereby improving the growth and yield of the crop. The water saved is to the tune of 20 to 30 per cent.

8. Moisture saving methods under limited water resource conditions:

The following methods may be adopted under limited water conditions to save water:

- a. **Water saving irrigation method:** Under limited water situations, water-saving irrigation methods like alternate furrow irrigation or widely spaced furrow irrigation and drip irrigation systems can be adopted in the absence of above said irrigation methods. Studies conducted on methods of irrigation in capsicum, tomato, okra and cauliflower indicated that adopting alternate-furrow irrigation and widely-spaced furrow irrigation saved 35 to 40 per cent of irrigation water without adversely affecting yield.
- b. **Mulching Practices in Vegetable Production** - The technique of covering the soil with natural crop residues or plastic films for soil and water conservation is called mulching. Mulching can be practiced in fruits and vegetable crops using crop residues and other organic material available in the farm. Recently plastic mulches have come into use due to the inherent advantages of efficient moisture conservation, weed suppression and maintenance of soil structure. Wide variety of vegetables can be successfully grown using mulches. In addition to soil and water conservation, improved yield and quality, suppression of weed growth, mulches can improve the use efficiency of applied fertilizer nutrients and also use of reflective mulches are likely to minimize the incidence of virus diseases. For vegetable production generally polyethylene mulch film of 30micron thick and 1 to 1.2 m width is used. Generally raised bed with drip irrigation system is followed while laying the mulch film.

9. Wind breaks, hedges and intercropping:

To overcome the adverse effect of high temperature and dry winds, tall growing trees need to be planted all along the boundary of the farm. Inter cropping of vegetable crops of the area can be practiced in orchards during summer months. Maize/ Sorghum can be grown all along the border of the plot to mitigate the effect of desiccating winds.

10. Use of protected cultivation of vegetables:

In peri-urban regions where climate does not favour year round production of crops in the open field, vegetable production can be taken up in protected environment. Protective structure is a facility to protect crop from biotic and abiotic constraints. Structures for protected cultivation include green houses, plastic/net houses and “tunnels”. Commonly used protected structures are polyhouses and net or shade houses. Rain-shelter is a simple structure covered with polyethylene sheet which helps in producing the crops which are affected by excessive rainfall. The productivity of tomato, onions and melons are adversely affected in the event of high rainfall due to difficulty in managing the foliar diseases, lack of proper soil aeration and drainage and also depending on the nature of crop physical damage of the foliage and flower drop. Net house cultivation and shade net cultivation provide better microclimate especially during summer in minimizing the high temperature effect and improving the relative humidity. The productivity of tomato, French bean and capsicum can be improved during high temperature period by using net/shade net on the top.

11. Control of leaf miner and mite during high temperature stress.

For management of leaf miner spray neem soap 4 grams / liter or triazophos at the rate 1.5 ml / l. To manage mites spray Abanectin 0.5 ml/l. Aphids may be observed in case of beans. Spray neem soap (1.0 %) or neem seed kernel extract (4.00 %).

Do's and Don'ts for Vegetable crops:

1. Establishing vegetation-free strips under the trees and between tree rows before growth begins.
2. In crop like Onion, drum seeder may be used for direct sowing.
3. Postpone transplanting of seedlings in the main field and also fertilizer application till the favorable soil moisture is prevailed.
4. Once the soil moisture condition becomes favorable transplanting of the seedlings may be taken up.
5. Resorting to foliar application of (water soluble) major nutrients.
6. Protection of young plants with partial shade.
7. In the inter spaces of crops weeding and inter-culture practices may be followed.
8. Thinning may be taken up to reduce the plant population.
9. Alternate furrow Irrigation may be taken up based on the availability of water.
10. Drip Irrigation may be followed. Pitcher irrigation wherever drip is unavailable for protective maintenance.
11. Plastic mulching and drip irrigation may be followed for better soil and moisture conservation and weed control.
12. Adopting the conjunctive use of surface and ground water as well as the use of nonconventional sources such as brackish water,
13. Waste water should not be utilized without pre treatment & safe reuse may be ensured.
14. Minimize use of those fertilizers which promote vegetative growth like nitrogen, use K and B as foliar spray to maintain plant turgor pressure.
15. Reducing water losses during conveyance and distribution,
16. Use of super absorbent polymers such as Luquasorb for water absorption and slow release.

7.1 "Parihar –Web Application for Direct Benefit Transfer (DBT) of input subsidy through Aadhar Enabled Payment System (AEPS)"

Shri.Gangaram Baderiya, IAS ,

Principal Secretary to Govt, Department of Revenue (DM), Govt. of Karnataka

Drought is a recurrent calamity that has bedevilled Karnataka over decades due to erratic monsoon and poor endowment of surface and ground water resources. The adverse impacts of drought are reflected in deteriorating nutrition status, urban migration and distress among cattle and farm animals. Frequent droughts have led to drop in agriculture and farm incomes thus having a debilitating effect on overall performance of the economy. Distributing **timely** financial assistance in terms of input subsidy to the distressed farmers during drought has remained one of the biggest challenges for the Government. The input subsidy will provide some succour to the aggrieved famers and enable them to buy seeds and other materials for the next cropping season.

Drought declaration signifies the beginning of Government response to conditions representing a drought conditions. The drought is declared using Taluk as a unit guided by objective parameters prescribed by the Drought Manual of Government of India that is in vogue during that period. The relief operation such as supply of drinking water, supply and transportation of fodder and employment generation, etc, are mounted in drought declared taluks using funds available in State Disaster Response Fund (SDRF) and State Fund. In most of the cases the drought is wide spread and is beyond the coping capacity of the State and memorandum is submitted to the Government of India seeking financial assistance from National Disaster Response Fund (NDRF). The Department of Agriculture, Cooperation and Farmers Welfare, Government of India will constitute and dispatch inter-ministerial central team (IMCT) to the drought affected area. The IMCT will visit drought affected areas in the State and interact with district and local officers, farmers and other concerned stakeholders. The IMCT will submit a report to sub-committee of National Executive Committee chaired by Union

Agriculture Secretary. The sub-committee of National Executive Committee (NEC) after studying the report will place its recommendation before High Level Committee (HLC) chaired by Union Home Minister. HLC approves the quantum of financial assistance (as per the NDRF norms) to be released to the State.

The input subsidy amount released from NDRF to the State is released to the PD account of respective Deputy Commissioners as per the demand in the Memorandum. The Deputy Commissioners in-turn release the amount to drought affected taluk based as per the joint survey report. Tashildar in coordination with Revenue Inspector and Village Accountant identifies beneficiaries and issues cheque or transfers money through RTGS/NEFT. This system was a **protracted delivery process** which invariably led to inordinate delay in providing input subsidy. There were instances in the past where input subsidy disbursement process took almost a year and a half. The major drawback of the systems is as follows:

- The process used to consume significant time and administrative resources as entire Revenue machinery in the taluk and district level are engaged in damage assessment and identification of beneficiaries, which used to impair other development works in the districts.
- Process was riddled with high amount of discretion at every stage leading to inequitably and inefficiently distribution, invariably leading to input subsidy amount given to unintended beneficiaries.
- Rent seeking from beneficiaries, illegitimate commission seeking by cutting edge level officers who had power to stop, deny or delay the benefit to be passed.
- Pressure on local banks leading to disruption of day to day operations, particularly in rural cooperative banks which lacks wherewithal in terms of technology and manpower to scale up the operations during disbursement.

To overcome the above stated drawbacks, extensive deliberations were held with experienced field level officers and all stakeholders. The outcome of which is development of “Parihara” web application which enables direct benefit transfer (DBT)

of input subsidy through Aadhar Enabled Payment System (AEPS). The application captures details of land details such as survey number, nature of crop, extent of land from Bhoomi database and additional information such as Aadhar number, Bank account number, contact details collected from farmers are entered into the database.

Problems faced during implementation and initiatives taken to over these

1. **Un-seeded Bank Accounts:** Nearly 40% (13 lakh) of beneficiary bank accounts were unseeded and few accounts even if seeded were not integrated with National Payment Cooperation of India (NPCI) database which enables payment through Aadhar Enabled Payment System (AEPS). The issue was taken with State Level Banker Committee at State Level and Lead Bank Managers at district level. Technical issue was also taken up with NPCI. Massive campaign at gram panchayat level for seeding the Aadhar with bank account was taken up. Posters were put up at Gram Panchayat office on how to seed bank accounts. SMS were sent to beneficiaries having unseeded bank accounts. 14 video conferences chaired by Development Commissioner and Addl. Chief Secretary and Principal Secretary, Revenue Department (DM and Bhoomi) conducted with Deputy Commissioners to review progress of seeding bank accounts. Nearly 12 lakh bank accounts were seeded in a span of 3 months.
2. **Name Mismatch in databases:** The biggest impediment in integrating different database in India is name mismatch due to different naming convention, initials unexpanded/expanded, changing of names after marriage. An algorithm has been developed in house which matches names from different database and assigns scores. The name/string matching algorithm has been developed in house by a serving IAS officer which has a vital component of Parihara Application. The impact of name/string match algorithm is clearly visible in weeding out lakhs of unintended beneficiaries in distribution of input subsidy for Kharif and Rabi. The algorithm has immense utility for all Government Departments in plugging leakages in DBT.

3. Wrong Aadhar seeding: Name mismatch database enabled identifying around 8,000 wrongly seeded bank accounts. Database clean-up was taken up to rectify wrong seeding by the banks.

Input Subsidy Disbursement before the advent of DBT(Parihara):

The input subsidy amount released from NDRF to the State is released to the PD account of respective Deputy Commissioners as per the demand in the Memorandum. The Deputy Commissioners in-turn release the amount to drought affected taluk based as per the joint survey report. Tashildar in coordination with Revenue Inspector and Village account identifies beneficiaries and issues cheque or transfers money through RTGS/NEFT. This system was a protracted delivery process which invariably led to inordinate in providing timely input subsidy. There were instances in the past where input subsidy disbursement process took almost a year and a half. The major drawback of the systems is as follows:

- The process used to consume significant time and administrative resources as entire Revenue machinery in the taluk and district level are engaged in damage assessment and identification of beneficiaries, which used to impair other development works in the districts
- Process was riddled with high amount of discretion at every stage leading to inequitably and inefficiently distribution, invariably leading to input subsidy amount given to unintended beneficiaries.
- Rent seeking from beneficiaries, illegitimate commission seeking by cutting edge level officers who had power to stop, deny or delay the benefit to be passed.
- Pressure on local banks leading disrupting the day to day operations particularly rural cooperative bank which lacked wherewithal in terms of technology and manpower to scale up the operations during disbursement.

After implementation of Parihara

- Timely payment: Electronic transfer of fund directly to farmers account from the State which minimizes intermediaries and will ensure timely payment.
- No pilferage: Accurate targeting and curbing pilferage by validating entries at multiple levels. Thus Parihara prevents malfeasance with input subsidy, which has been an biggest challenge for the governments.
- Transparency: Beneficiary can check the payment status by keying his/her Aadhaar No or user ID (unique ID assigned to farmers during data entry). Details such as input subsidy amount paid, to which bank, account no, extent of crop loss and name of the crop will be displayed on keying in above numbers. This enables eligible small and marginal farmers to approach the designated authorities with a sense of entitlement in case of non-receipt of input subsidy.
- Efficient: Less than 1% rejection in payment: Aadhaar number of the affected farmers are linked to the Bhoomi database after taking due consent from the farmers. Yes or no Aadhaar validation with UIDAI server to ensure Aadhaar no entered is a valid Aadhaar no and Aadhaar seeding status is checked with NPCI mapper Database. These validations enable intimating the beneficiaries about the linking status and taking remedial measures.
- Monitoring: Robust MIS to monitor the progress and to provide quick and convenient method for grievance redressal.
- This is a onetime data entry, hence burden on district administration will reduce considerably for future disbursement of input subsidy. Thus there will not be disruption on developmental works.
- Parihara eliminated intermediaries, weeded out fictitious beneficiaries and discretion of government officials to stop, deny or delay the benefit to be passed and to a great extent enhanced **financial inclusion** by opening new bank accounts.

The Parihara has had positive spin-offs as well and these are as follows:

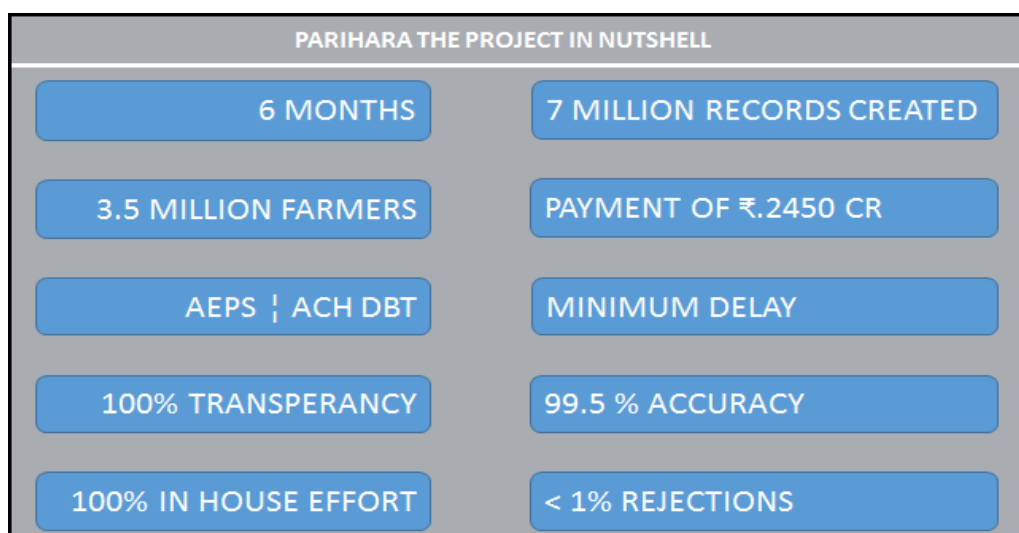
- Robust farmer-level data generated can be useful for planning purposes by all concerned agencies.
- Updation of crop details in the RTCs, which will facilitate accurate yield estimation.
- Success of Parihara has had cascading effect on other State Government schemes which involves disbursement of subsidies.

Evolution of Parihara Application

What started as excel sheet format for data collection for crop damage evolved into a most sophisticated web application “Parihara” to ensure a better and timely delivery of financial assistance in terms of input subsidy directly into the accounts of beneficiaries thereby plugging leakages and enhancing financial inclusion.

Parihara application was developed within a short span of 2 months involving in house human resources. 20 software engineers worked more than 12 hours daily.

It goes without saying that key to any technology intervention is effective implementation. There were, nevertheless, two major challenges in implementing Parihara. The first challenge was to creation (data entry) of 7 million records in quickest possible time and second to ensure integrity of data entered. Around 15 video conferencing was held to sensitize the district admin about the application and review data entry status under the Chairmanship of Development Commissioner cum Addl. Chief Secretary/Add. Chief Secretary E-Gov/Principal Secretary, Revenue Department (DM) with Deputy Commissioners of drought affected districts. A record 5 million records were created in Parihara in span of 4 months.

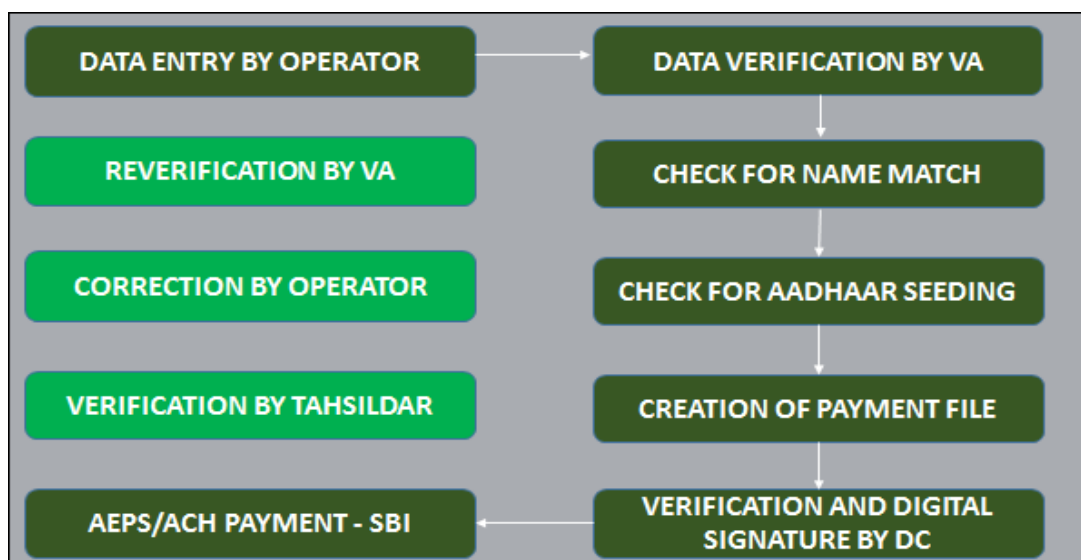


Salient features of Parihara Application

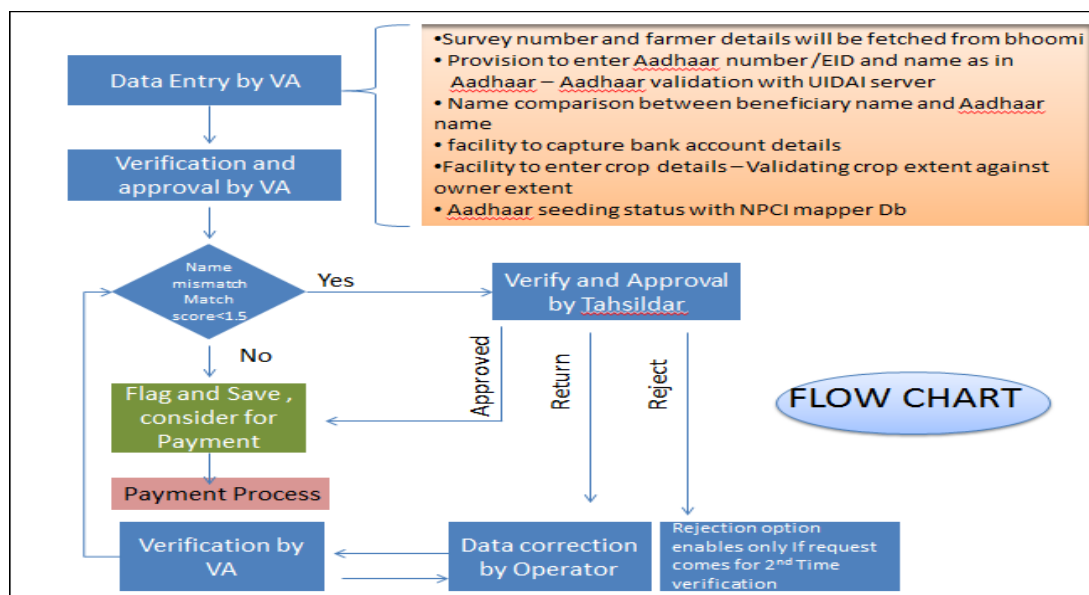
- The Parihara application fetches land details(survey no., extent,etc,), owner details from Bhoomi database. Bhoomi Database forms the backbone of this application. Crop details and extent of damage is validated using Bhoomi database, which ensures payment to intent beneficiaries, i.e., to farmers who really owns the land. This feature ill eliminate unintended beneficiaries.
- Aadhaar number /Enrolment ID and name as in Aadhaar of the affected farmers after taking due consent from the farmers. Yes or no Aadhaar validation with UIDAI server to ensure Aadhaar no entered is a valid Aadhaar no. Aadhaar seeding status is checked with NPCI mapper Database, which enables intimating the beneficiaries about the linking status and taking remedial measures. This shall facilitate Aadhaar Enabled Payment System (AEPS), most secured, transparent financial instrument for disbursing input subsidy.
- Beneficiary can check the payment status by keying his/her Aadhaar No or user ID (unique ID assigned to farmers during data entry). Details such as input subsidy amount paid, to which bank, account no, extent of crop loss and name of the crop will be displayed on keying in above numbers. This enables eligible small and marginal farmers to approach the designated authorities with a sense of entitlement in case of non-receipt of input subsidy.

Parihara Workflow

The work flow is depicted in the below given flowchart. Data entry of land details, extent of damage, Aadhar number, bank details, etc, is made by the data entry operator. This is verified by Village Accountant and approved. In case there is mismatch between name in RTC and Name in Aadhar database, the record is escalated to Tashildar to verify and approve. Once approved, XML file is created and digitally signed by respective Deputy Commissioners and uploaded for payment.

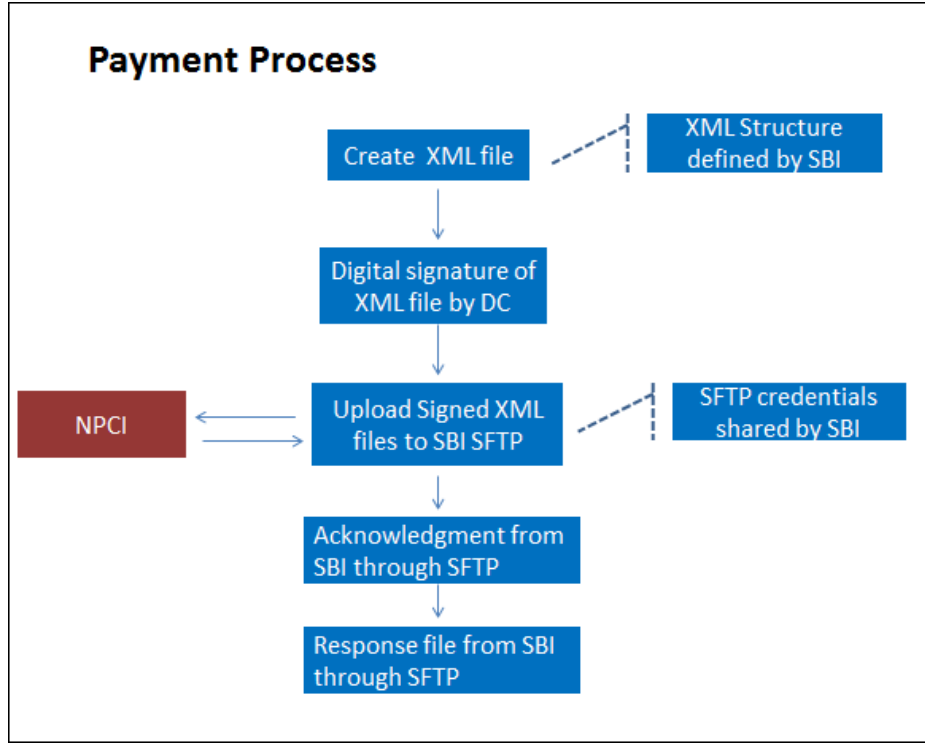


Flow chart depicting verification process



Payment Process in Parihara

Robust mechanism has been developed to ensure transparency and integrity in payment process and flow chart is as follows:



As on today, Rs.2480.47 crore disbursed to 35,41,655 farmers till date using Parihara application.

Transparency: Beneficiaries can check the payment status by keying in either aadhar no or user ID in portal given below. The screen shot of the sample output is given below.

<http://landrecords.karnataka.gov.in/PariharaPayment/>

ಪರಹಾರ ಸಂದಾಯದ ವಿವರಗಳು/Payment Details										
ಕ್ರಮ ಸಂಖ್ಯೆ/ SI No	ಜಿಲ್ಲೆಯ ಹೆಸರು/ District Name	ಬ್ಯಾಂಕಿನ ಹೆಸರು/ Bank Name	ಮೊತ್ತ/ Amount (₹)	ಖಾತೆದಾರನ ಹೆಸರು/ A/c Holder Name	ಬ್ಯಾಂಕ್ ಅಕೌಂಟ್ ನಂಬರ್/ Bank Account Number	ಪರಹಾರ ಸಂದಾಯದ ಸ್ಥಿತಿ/ Payment Status	ಸಂದಾಯದ ದಿನಾಂಕ/ Payment Date	ಸಂದಾಯದ ವಿವರ/ Calamity Type	ಸಂದಾಯದ ಕಾಲ/ Season	ಸಂದಾಯದ ವರ್ಷ/ Year
1	Gadag	STATE BANK OF INDIA	13599	MR PARVATAGOUD SANGANAGOUD SHAMBNAGOUDAR	XXXXXXXX184	00-Success	15/Sep/2017	DROUGHT	RABI	2016-17

ಪರಿಹಾರ ನಮೂದಿನ ವಿವರಗಳು/Details Of Parihara Entries										
ಕ್ರಮ ಸಂಖ್ಯೆ/ SI No	ನಮೂದು ಸಂಖ್ಯೆ/ Entry ID	ಆಧಾರ್ ಸಂಖ್ಯೆ/ Aadhaar No	ಜಿಲ್ಲೆಯ ಹೆಸರು/ District Name	ತಾಲ್ಲೂಕು/ Taluk Name	ಹೋಬಳಿ/ Hobli Name	ಗ್ರಾಮ/ Village Name	ಸರ್ವೆ ಸಂಖ್ಯೆ/ Survey Number	ಬೆಳೆ ಹೆಸರು/ Crop Name	ಬೆಳೆ ವಿಧ/ Crop Category	ಬೆಳೆ ನಷ್ಟದ ವಿಸ್ತೀರ್ಣ (ಎಕರೆ-ಗುಂತಾ-ಫುಂತಾ) /Crop Loss Extent (Acre-Gunta-Fgunta)
1	5537979	XXXXXXXXXX451	ಗದಗ	ಗಜೇಂದ್ರಗಡ	ನರೇಗಲ್	ಕುರಚಗಿ	98 / * / 5	ಕಡಲೆ	Rainfed	5 - 0 - 0.00

8.1. “Samrakshane” - End to End Workflow Based e-Governance Solution for Management of Crop Insurance

Introduction & Brief Overview

Agriculture in Karnataka is prone to variety of risks, thanks to more than 66% percent of Agriculture area dependent on rain fed system. Karnataka has been continuously reeling under drought for six years and in last 16-years nature has been kind only 3 times. 78 % farmers are small and marginal and therefore suffer much more from such risk. Climate change is adding to the complexity of the problem.

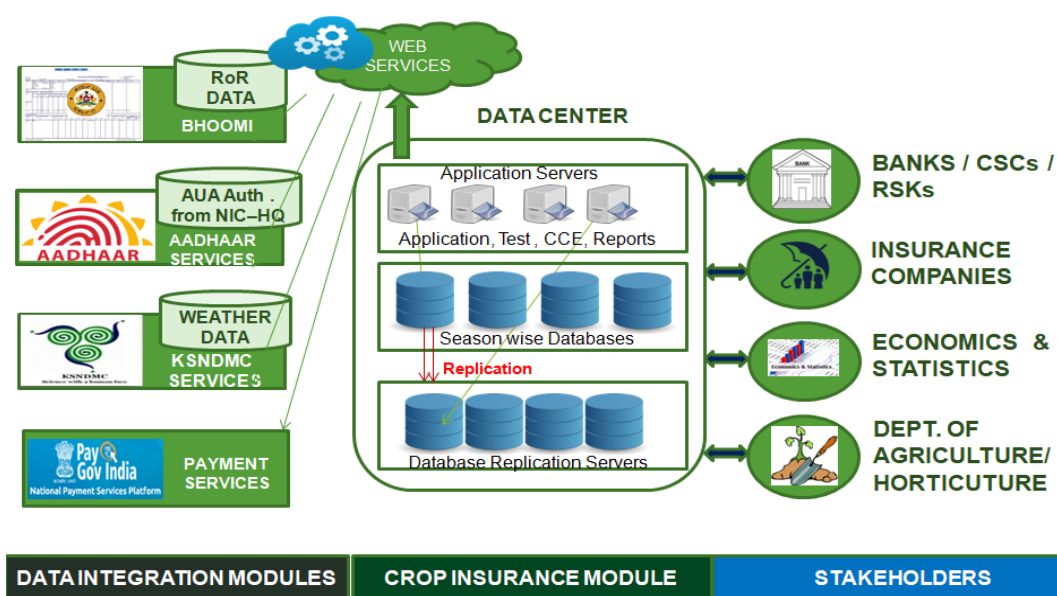
It is in this background that efficient Crop Insurance system; acquire much more relevance and importance. A well designed Crop Insurance system which is transparent and quick in providing relief largely de-risk the farmers and helps in even catalyzing private investment / capital formation in Agriculture sector. The Government of India realized the short comings in NAIS and MNAIS (earlier crop insurance schemes) and introduced Pradhan Mantri Fasal Bima Yojane with new features.

The coverage of Crop Insurance Schemes in Karnataka has been one of the lowest amongst other States. The average number of farmers covered has not exceeded 15 % in Kharif and 30-40% in Rabi with most of the covered farmers as loanee farmers (65% of total insured farmers). The reasons are not difficult to understand. The involvement of Agriculture and Horticulture Department in Scheme implementation was minimal with its role largely limited to issue of Crop Insurance notifications and release of some advertisement. District administration involvement was also to say the least, minimal. Collector hardly owned the schemes. Perhaps they were never impressed upon regarding this priority of State Govt. The insurance agencies worked with banks and a very opaque and closed system existed with no information on details of covered farmers, the lands or the crop was available with the State Govt. The system of Crop Cutting Experiment was again extremely neglected and opaque. Manual system ensured that yield data came as late as three months after crop harvest was over with no way for any stakeholder including farmers to verify or challenge the correctness of data. The claim settlement was always delayed by months together. There was no way for

Government or farmers to know which all farmers got the claims and when they actually got the money into their bank account.

The farmers, rightly so had therefore lost all interest in Crop Insurance scheme. After understanding the above serious short comings as detailed above it was decided to work towards evolving an e-Governance solution called “Samarakshane”

Components of Samrakshane IT system



First, the system facilitates online registration of Crop Insurance request by farmers using bank computers or Gram panchayat computers or Raita Sampark Kendras (farmer’s facilitation centers of Agriculture Dept.).

Secondly a mobile app is developed as part of IT system to be used by 15000 primary workers of four departments to carry out crop cutting experiments (CCE). The mobile app captures the video, photos, latitude and longitude of the plot and also has features to validate whether the CCE was indeed carried out in the prescribed survey number. The yield data of the experiment goes out and sits immediately in Samrakshane database, (so that the IT system can calculate automatically in which Insurance Units (Gram Panchayat), the yield was below the ‘threshold yield’) thus removing opportunities to the officials involved in CCEs to manipulate the yield data in

advantage of farmers’/ insurance company making the farmers of that IU eligible for payment.

The third and most important component of IT system put in place is the mechanism for quick and fast settlement of claims of the farmers including handling of events like prevented sowing, midterm adversity, localized risks and post-harvest losses. The IT system generates list of farmers whose claims needs to be settled along with details like Aadhaar number, Bank Account number, IFSC code, Crop, Amount to be paid etc. MIS reports are created in the various format required by NPCI / Banks for AEPS / NEFT so that no further processing is required by Insurance agency for payment.

The last critical component is crop verification mobile app. The app facilitates Department official to verify the crop in the field with crop insured. The photograph with GPS co-ordinates are transferred to central IT control system, wherein it is compared with Geo referenced cadastral map to ensure that crop is seen in right place (survey number). In case of difference between what was actually grown and what was registered for Insurance, the premium paid by farmer would be forfeited. This would ensure that genuine farmers are insulated from unscrupulous farmers and no ‘acreage discrepancy factor’ gets applied. More than 18000 bank officials and 15000 primary workers were trained directly and through master trainers which helped in easy switch on to IT system from manual systems.

Electronic integration of Samrakshane IT system



Samrakshane connect to various IT systems

- Connects to Land records (Bhoomi) to avoid enrolment in excess of owned land and fake enrolment – Fake RoRs
- Connects to AADHAAR for authentication of identity and for verifying Financial Address – AEPS
- Connect to “Pay Gov” for transfer of farmers’ premium to Insurance Companies
- e-Sign of proposal & acknowledgement
- Integration with digilocker for pushing farmers’ insurance documents
- Connects to Karnataka State Natural Disaster Monitoring Center for weather data requirement
- SMS gateway sending SMS to farmers indicating the status of their proposals at various important stages.

Manual System vs Samrakshane IT system

Activity	Manual System	Samrakshane
Check the status of enrolled number of farmers during the season	✗	✓
Check the status of enrolment	✗	✓
Know the Government and farmer’s share of premium at any point of time within the cut off date	✗	✓
Notifications to farmers on status of various activities under the crop insurance	✗	✓
Ensuring farmers don’t insurance their crops multiple times on same land	✗	✓
Availability of report on ‘uncovered farmers and lands’	✗	✓
Payment to farmer’s account / Aadhaar seeded bank account	✗	✓
Awareness to farmers about compensation details	Partially	✓

9.1 Strategic Role Played by KSWC in Drought Management



Karnataka State Warehousing Corporation

“BheejaBhavan Building”, 4th& 5th Floor, Bellary Road, Hebbal, Bangalore – 560 024

Fax: 080-23415672, E-mail: gmcom.kswc@gmail.com, Phone : 080-23415679

Web:www.karnatakawarehousing.in

Karnataka State Warehousing Corporation was established in 1957 under the Agricultural produce (Development and Warehousing) Corporations Act 1956, to store agricultural produce, seeds, manures, fertilizers, agricultural implements and other notified commodities in the warehouse centers and preserve them scientifically. It has the large potential with the storage capacity of 14.13Lac MTs of Scientific warehouses and it will rise to 25Lac MTs of storage capacity by the end of Sep 2018. Majority of the scientific warehouses are situated in the APMC Yard, taluk and District headquarters. It has vibrant transportation & logistic facility, well-connected between taluks, Districts, National/State highways. Warehouse receipts issued by KSWC are considered as negotiable instrument and serve farmers and depositors to avail pledge loan.

During 2001, Government of India had started SGRY scheme (Sampoorna Grameena Rozgar Yojna) to ensure that every poor people in the rural area gets employment and food. As it was Government programme meant for creating employment to the rural poor in drought hit places, The Corporation had played a vital role in storing of food grains and lifted of 4, 60,564 MTs of food grains for distribution under the public distribution system from 1st phase to the 11th phase in the following mentioned drought hit districts Bangalore(R), Shimoga, Uttarkannada, Chitradurga, Dharwad, Koppal, Bagalkot, Gulbarga and Bidar. In Addition to this, the Corporation had also supported the Government in other drought prone districts of Karnataka by providing storage space for storing food grains distributed under SGRY scheme by other Government agencies in the State.

10. Drought Management Strategies – Best Practices

Government of Andhra Pradesh

Introduction:

Andhra Pradesh is one of the most vulnerable State in India to multiple natural disasters like Cyclones, Heavy Rains and Floods, Hailstorms, Tsunamis on one hand and Drought on the other hand, in view of its widespread and peculiar geographical location. The State has about 974 kms of coast line, longest on the Eastern Coast and second largest in the Country next to the Western coast State of Gujarat. The total coastal area is spread over 95,669 Sq. kms in the nine Coastal Districts – Srikakulam, Vizianagaram, Visakhapatnam, East Godavari, West Godavari, Krishna, Guntur, Prakasam and SPSR Nellore. The total Rayalaseema area is spread over 67,301 Sq.KMs in the four Districts – Chittoor, YSR Kadapa, Ananthapur and Kurnool.

As per Census-2011 and projected population for 2017, total population of the State is 510.41 lakhs, of which 69.2% is in nine coastal districts and 30.8% is in 4 districts of Rayalaseema region.

1. Background:

Ananthapur, Chittoor, Kadapa, Kurnool and Prakasam Districts are Drought Prone areas in the State. Since 1996, the State has witnessed Drought in 16 years out of 21 years. The years 1998-99, 2005-06, 2007-08, 2008-09 and 2010-11 are drought free in the State. Number of Mandals declared as drought affected in each of these years is indicated in brackets:- 2002-03(641 Mandals), 2009-10 (626), 2001-02(589), 1997-98 (487), 2011-12 (460), 1999-2000 (444), 2004-05 (408), 2015-16 (359), 2003-04 (302), 2016-17 (301), 2014-15(238), 2012-13 (218), 2006-07 (195), 2013-14 (123), 2000-2001 (112), 1996-97 (13). District wise number of mandals declared as drought affected from 1996-97 to 2016-17 are shown below (Table.1).

**Table.1 Districtwise, Yearwise No of Mandals declared as
Drought Affected 1996-97 to 2016-17**

Sl. No.	District	Total Mandals	1996-97	1997-98	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05
1	Kadapa	51		50	51	5	51	51	32	49
2	Chittoor	66		32	65	45	65	65	42	56
3	Prakasam	56		56	56		43	56	39	53
4	Anantapur	63		63	63		63	63	62	53
5	Nellore	46		36	46	18	46	46	40	40
6	Kurnool	54		54	53		52	54	31	46
7	Vizianagaram	34	2	34	34	17	34	34	11	6
8	Srikakulam	38	11	37	36	16	38	28	11	8
9	East Godavari	60		17	5	11	45	53	3	20
10	Visakhapatnam	43		41	28		42	42	7	7
11	West Godavari	46		10			24	42	10	25
12	Guntur	57		37	7		53	57	1	24
13	Krishna	50		20			33	50	13	21
	TOTAL :	664	13	487	444	112	589	641	302	408

Sl. No.	District	2006-07	2009-10	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
1	Kadapa	33	51	51	43	16	33	51	32
2	Chittoor	37	66	49	28	33	39	54	66
3	Prakasam	32	56	56	35	4	21	56	56
4	Anantapur	63	63	63	63	63	39	63	63
5	Nellore		46	9	9	2	14	33	27
6	Kurnool	30	49	54	36		40	40	36
7	Vizianagaram		19	15		5		3	6
8	Srikakulam		26	30			10	18	15
9	East Godavari		58	14				0	
10	Visakhapatnam		42	31				0	
11	West Godavari		46	15				0	
12	Guntur		55	41	4			26	
13	Krishna		49	32				14	
	TOTAL :	195	626	460	218	123	196	358	301

2. Drought Management Strategies adopted:

Owing to the extent of the drought situation in the state, Andhra Pradesh is currently following the manual for drought management, 2016 by Ministry of Agriculture, Government of India for understanding, monitoring, declaring, providing relief to mitigate drought.

A few of the mitigation measures and drought relief taken by the state to minimize the impacts are as follows;

a) Relief Employment under MGNREGS:

Provision of employment is an important drought mitigation measure in the State. Mahatma Gandhi National Rural Employment Guarantee (MGNREG) Act provides legal guarantee of providing up to 100 days of wage employment to rural households whose adult members are willing to do unskilled manual labour. At present, the Scheme is implemented in 655 mandals of 13 districts. Due to drought, agricultural operations are reduced substantially, restricting the scope of seasonal employment. Government of Andhra Pradesh has declared 230 mandals as drought affected mandals. It is therefore, necessary for the State Government to immediately start relief employment programs and provide works to those who need employment within a radius of five kilometres. Income generation through these employment works helps the poor labourers to meet their basic needs such as food and health expenditure.

As a lead agency the Rural Development Department has taken the following initiatives under MGNREG Scheme in the Drought declared Mandals which are drought affected.

- The existing shelf of works would be sufficient for additional person days also.
- Works have been opened in all Gram Panchayats of drought hit Mandals.
- To monitor continuously, **Drought cells** were established at State/ District level.
- State level Officers were deployed as Special Officers for these drought affected districts.

- Toll free telephone numbers were established for receiving grievances such as demand for work.
- To provide wage employment to those households who have already completed 100 days, a proposal requesting GoI to provide employment up to 150 days in drought Mandals has been sent for fund assistance.
- Exclusive MIS Report on progress of Drought Mandals is placed in the web, to monitor daily labour reported and for opening up of works in Gram Panchayats.

b) Provision and Distribution of Food Grains:

Food grains are provided through Public Distribution System (PDS), which is operated under the joint responsibility of the Central and State Governments. Andhra Pradesh has an extensive network of PDS spanning 28985 fair price shops located in the remotest and inaccessible pockets of the State catering to the needs of 1.29 Cr BPL families.

c) Availability and Supply of Drinking Water:

Drinking Water is being provided in rural areas by the Department of Rural Water Supply & Sanitation (RWS&S) through hand pumps (183000) , Protected Water Supply (PWS) Schemes (28173) & Comprehensive Protected Water Supply (CPWS) Schemes (463) covering cluster of habitations. Additionally, 345 private bore wells are hired for the supply of drinking water in 345 habitations with a maximum of 225 in by Chittoor, Kadapa (111) and Ananthpur (9).

As for urban water supply, there are 97 Municipalities and 13 Municipal Corporations in residuary Andhra Pradesh State. The maintenance of Water Supply in 97 Municipalities and 13 Municipal Corporations (Total 110 ULBs) is under the respective Municipalities / Corporations.

d) Implementation of Temporary Water Supply Schemes:

In Rural areas, 230 mandals were declared as drought affected in 2014. Special attention is being paid to mitigate the drinking water problem in all districts in the State including the above mentioned mandals in 7 districts by transportation of water through tankers, deepening & flushing of bores and hiring of private sources etc.

In 97 Municipalities and 13 Municipal Corporations in residuary Andhra Pradesh State, water is being supplied through 4776 power bore wells and 34910 bore wells fitted with hand pumps in addition to providing Drinking Water from protected Water Supply Schemes. On an average, water is being transported through 1439 trips per day with 177 tankers to the problematic areas in the State.

e) Information on Cattle Camps and Fodder Depots:

Livestock farming is the backbone of the rural economy and act as drought insurance. 70% of the Small & Marginal Farmers and Agricultural labourers depend upon livestock rearing. With the changing socio climatic environment, farmers are shifting from traditional agriculture to livestock farming as the livestock farming is providing more sustainable livelihood and supplementary income. The following are the mitigation measures taken up by the government;

- The Animal Husbandry Department has supplied 23710 Qtl,s of fodder seed in the State under RKVY and other Schemes and further requirement of fodder seed by the districts is made available.
- Drinking water to the Livestock is ensured by maintaining the existing drinking water troughs in villages.
- An amount of Rs. 3.00 crores towards fodder seed supply has been incurred as part of relief operations under RKVY Kharif Action Plan-2014.

f) Other Relief and Mitigation Measures:

- ❖ Agriculture Department implemented district wise crop contingency plans.
- ❖ **Control rooms** were opened at Mandal and district level in all drought affected areas involving agriculture, revenue and all concerned departments.
- ❖ Separate control rooms are opened by Agriculture Department at Mandal as well as at district level to solve the grievances of farmers and to provide helpline.
- ❖ Joint teams consisting of revenue and agriculture officials have been constituted at village level to enumerate crop damages and prepare list of eligible beneficiaries for disbursing input subsidy.

- ❖ Supervisory teams consisting of revenue and agriculture officials have been constituted to supervise the enumeration work and list of beneficiaries prepared by the village officials.
- ❖ Teams have been constituted at district level also with senior officials to scrutinize list of beneficiaries reported by the mandals officers.
- ❖ Detailed guidelines were issued by the Commissioner for Disaster Management to all districts to display the list of beneficiaries at panchayat offices/chawadi and also to maintain these lists at Mandal level so as to provide information to public on demand.

3. Implementation of Technology:

A very important part of planning for drought is the provision of appropriately-timed and reliable climate information, including seasonal forecasts, that aids decision makers at all levels in making critical management decisions. This information, if properly applied, can reduce the effects of drought and other extreme climate events. The wide range of data and information that is available to users via the Internet has made the development of a consolidated climate supervising system a more executable job. Utilizing the GIS technology and services; it is possible to explore the extent of drought in a region.

Careful monitoring of the symptoms of drought and early warning are key to effective management of the calamity. The development of such a system and its success depends on the coordinated efforts on the part of all affected parties viz. Government of India, State Governments, Scientific Institutions and farmers who are the key stakeholders in the mitigation phases.

Central Agencies -

- i. Central Drought Relief Commissioner: A Drought Management Cell in the DM Division is created to help collate information for diverse sources, monitor drought conditions, issue advisories, coordinate with other Ministries of the

Central Government, State Governments and relevant agencies to mitigate/combat the effect of drought.

- ii. Crop Weather Watch Group: The CWWG is responsible for the evaluation of multi-source information and data from scientific and technical bodies to determine the likely impact of meteorological and other environmental parameters on agriculture.

State Agencies –

- i. State Drought Monitoring Centers: Drought Monitoring Centres (DMCs) staffed by a multi-disciplinary team of meteorologists, hydrologists and agriculture scientists provides critical inputs to the State Executive Committee / State Disaster Management Departments / Other Institutional Structures established by the States. The DMCs will collect, collate and analyse information on drought parameters from National and State level agencies e.g., the IMD, NRSC/ SRSCs, MNCFC, CWC, CGWB, State agricultural department etc.

Scientific and Support Organizations –

- i. **India Meteorological Department (IMD):** IMD provides, inter alia, national weather based services for weather-sensitive activities like agricultural and is the principal government agency in all matters related to meteorology, seismology and allied subjects.
- ii. **Mahalanobis National Crop Forecast Center:** MNCFC, operationally, carries out drought assessment and monitoring under the National Agricultural Drought Assessment and Monitoring System (NADAMS) after the technology was transferred from the National Remote Sensing Centre in the Department of Space (Government of India).
- iii. **Central Research Institute for Dryland Agriculture (CRIDA):** CRIDA take part in drought studies pertaining to assessment, mitigation, risk transfer, and development of decision support software for drought-prone States.

- iv. **Indian Space Research Organisation (ISRO):** ISRO provides R&D and technical support for drought assessment/monitoring activities through satellite data products available on Meteorological and Oceanographic Satellite Data Archival Centre (MOSDAC) and Bhuvan platforms.
- v. **State Remote Sensing Application Centres (SRSACs):** The state remote sensing agencies help the State Governments in satellite data analysis for agricultural drought assessment.

4. Best practices:

A **software** has been developed recently to **monitoring the drought situation** prevailing in the State from time to time. The Mandatory and Impact indicators data is to be uploaded by the concerned departments at State / District level on periodical basis, so that the drought situation may be identified at early stage.

Another **soft ware** has also been developed to **monitoring the mitigation measures** being implemented by the Line departments whenever the drought situation occurred in the State. Mandal as a unit to implement the mitigation measures, Login Ids and Passwords are provided to Mandal / District/State level departments concerned to upload the data on periodical basis.

11. Drought Management Strategies - Best Practices

Government of Bihar

1. Background:

Agriculture is key to the development of Bihar's economy as more than 77% of the population of the state are dependent on agriculture and its allied activities. Agriculture contributes 18% to the state GDP. On the other hand, Bihar is a multi-hazard prone state and flood and drought / drought like situation are experienced in the state affecting the productivity and in turn the livelihood of the population dependent on agriculture and its allied activities.

Bihar with a geographical area of about 94.2 thousand square km is divided by river Ganges into two parts, the north Bihar with an area of 53.3 thousand square km and the south Bihar having an area of 40.9 thousand square km. Based on soil characterization, rainfall, temperature and terrain, four main agro-climatic zones in Bihar have been identified (Figure 1). The districts of North Bihar are generally considered as flood prone whereas the south Bihar districts are considered as drought prone.

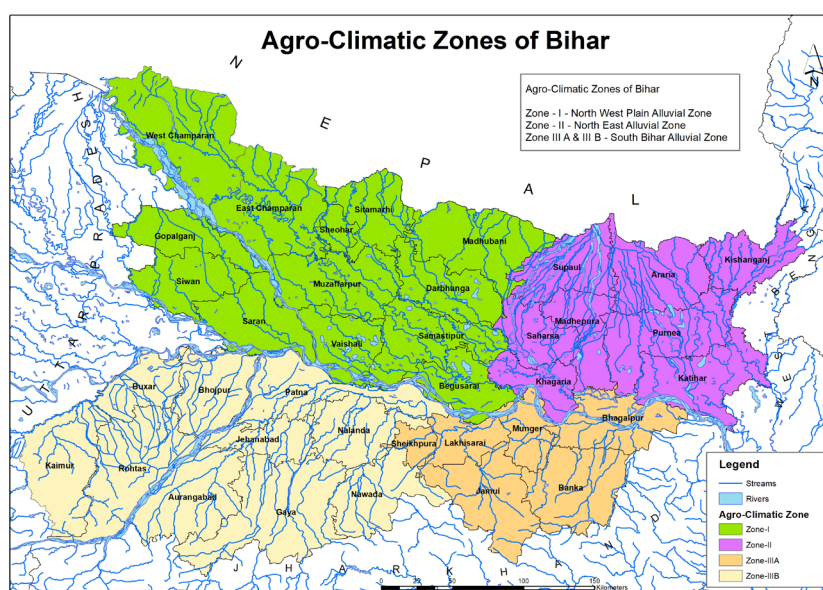


Figure 1: Agro-climatic zones of Bihar with major drainages of the state

A unique paradox is witnessed in Bihar wherein flood and drought events occur in the same year (2013) and sometimes in the same district. Though districts lying to the south of Ganges are considered drought prone, of late the incidence of drought / drought like situation has even spread to North Bihar (2009) districts (Bihar DRR Roadmap 2015-30).

In addition to currently known hazards in Bihar, extreme weather events, changes in temperature and precipitation and uncertain weather patterns are also increasingly being witnessed, with reported adverse impacts on agricultural produce and increased incidents of localised droughts and floods.

In the last decade, Bihar experienced drought on 5 occasions with 2010-11 being the worst when all the 38 districts experienced drought and in 2013-14 when 35 districts were drought affected. Table 2 shows the list of districts affected by drought in the last one decade.

Year	Districts affected
2004-05	Bhojpur, Buxar, Rohtas, Kaimur, Patna, Gaya, Nalanda, Aurangabad, Jehanabad, Arwal, Vaishali, Saran, Siwan, Gopalganj, Banka, Munger, Sheikpura, Jamui, Lakhisarai, Nawada
2006-07	Gaya, Aurangabad, Nawada, Jeahanabad, Arwal
2009-10	Bhojpur, Buxar, Rohtas, Kaimur, Patna, Gaya, Nalanda, Aurangabad, Jehanabad, Arwal, Vaishali, Saran, Siwan, Banka, Munger, Sheikpura, Jamui, Lakhisarai, Nawada, Bhagalpur, Kishanganj, Begusarai, Vaishali, Madhepura, Muzaffarpur, Katihar
2010 – 11	All 38 districts
2013 – 14	Bhojpur, Buxar, Kaimur, Patna, Gaya, Nalanda, Aurangabad, Jehanabad, Vaishali, Saran, Siwan, Munger, Sheikpura, Jamui, Lakhisarai, Nawada, Bhagalpur, Begusarai, Vaishali, Madhepura, Muzaffarpur, Katihar, Gopalganj, West & East Champaran, Madhubani, Sitamarhi, Sheohar, Supaul, Purnia, Darbhanga, Samastipur, Saharsa.

2. Drought Management Strategies adopted:

Drought is a very complex disaster which initiates at a very slow pace and it is very difficult to assess its end as well as its extent. In view of this complexity the government has taken up a number of strategies to counter the negative effect of drought to secure the livelihood of the farmers.

1. Agriculture Road Map: Department of Agriculture through its Directorates and with the technical guidance of the Agricultural Universities act as delivering vehicle to reach the benefits of technological advancements as well as research findings to the last mile involved in farm activities. The Department carries out capacity building as one of the important activities for farmer's /extension functionaries/rural youth through ATMA & KVK to enable them to adopt improved agriculture practices and new technologies. The planned efforts are implemented by the department through well-articulated Agricultural Road Map since 2008. The Roadmap includes strategies for drought management with defined physical and financial targets which includes water management, increasing irrigation potential, distribution of drought tolerant seed varieties to farmers and diesel subsidy to farmers during *kharif* and *rabi* season.
2. Bihar DRR Roadmap 2015-2030: Bihar is the first state in India to prepare a road map for disaster risk reduction with an aim to reduce economic losses to the tune of 75% of the present value in line with the Sendai agreement amongst other targets. Drought is one of the major disaster which has been considered while formulating the targets of the DRR Roadmap. The roadmap has five building blocks to achieve resilience to disasters and capacity to build back better. Amongst the five building blocks resilient villages and resilient livelihood incorporates strategies to be taken up by the Department of Agriculture to mitigate and respond to drought through measures like water conservation, risk assessment of the agriculture sector to drought, augmentation of irrigation potential to mitigate the adverse impacts of deficient precipitation due to climate change and other natural causes in line with the strategies of the Agriculture Road Map.

3. Department of Disaster Management, Government of Bihar as part of its strategy to support the farming community during drought has developed a Standard Operating Procedure to identify responsibilities of line departments, data analysis and management, identification of line of communication for decision makers, allocation of responsibilities to support vulnerable groups and identification of agencies for relief and support. As part of the SOP a Crisis Management Group has been created under the chairmanship of the Chief Secretary of the State as a decision making body during drought. Principal Secretaries / Secretaries of eighteen line departments including agriculture, water resources and minor water resources are member of the crisis management group. The SOP includes Watch / Alert indicator, warning indicator, emergency indicator and acute indicator of drought based on Crisis Management Plan provided by the Department of Agriculture, Govt. of India. The SOP incorporates action plan in case of deficient and scanty rainfall, dry spell, early withdrawal of monsoon and no rainfall. The communication channel from state to block level and vice versa is also well defined in the SOP so that information can reach the last mile at the correct time.
4. Soil and Water Conservation: The department implements a well-defined soil and water conservation programme in the drought prone southern districts of Bihar under various central and state sponsored schemes.
5. Diesel Subsidy: The department of agriculture has a well-defined contingency plan during the kharif and rabi season by means of providing diesel subsidy to farmers for irrigation using groundwater resources in case drought like situation.

3. Implementation of Technology:

A number of research and development is also being carried by the research community to help the farmers by means of development of short and drought tolerant paddy varieties. One of success is the *sahbhagidhan* having a growth period of 105-110 days duration in plain areas and 110-115 days in uplands, highly resistant to leaf blast and moderately resistant to brown spot and sheath blight. The farmers get an average

yield of 34.6 q/ha with a yield advantage of 26% over traditional long duration variety in seasons that experience deficit rainfall. In view of the two major droughts in the recent years in 2015 kharif season the department distributed the *sahbhagi* variety in all the districts of Bihar to cover around 117409 acre. Zero tillage technology is also being implemented for direct seeding of rice with a target to cover 53500 acre. In view of ensuing effect of climate change the department is stressing on crop diversity with increasing coverage of maize, *arhar* (pulses) and bajra and seed distribution mechanism have been initiated.

4. Impact of implemented Technologies in minimising losses & improve coping capacity of the Community:

A number of measures taken as part of the strategies of drought management for minimising loss and improving coping capacity is described below:

1. SRI method for paddy cultivation help in getting paddy crop in scanty rainfall area as it is dry & wet method. But due to spacing & timeliness of transplanting there is profuse tillering resulting in good yield of paddy.
2. Introduction of drought resistant *var. Sahbhagi* developed by IRRI has been popularised in drought prone districts of Gaya, Nawada, Jamui, Banka, Nalanda other districts of south. It helped in mitigating drought due to short duration and also enabled farmers to sow the rabi crop within the schedule time.
3. *R Bhagwativar* of paddy was popularised in upland areas as it is short duration variety thus helping in timely sowing of rabi crops. It can also withstand short dry spells which is a common occurrence in North Bihar.
4. Two contingent variety of paddy of duration 60 – 100 days (*Prabhat* and *Turanta var.*) has been introduced which improves crop coverage in drought situation.
5. Community nursery of paddy has been established in each block in 2 places of 5 acre each. Subsidy of Rs 7240 per five acre is provided to CN farmer and Rs 1000 per one acre to end user farmers for purchase of seedling from CN. This results in

availability of paddy seedling even if there is delay in monsoon & start of drought condition. It helps in coverage of paddy area in short dry spells also.

6. To explore potential ground water for irrigation in drought condition Diesel subsidy for 3 irrigations in paddy and wheat / two irrigation in other crops has been given to farmers. Each irrigation with 10 litre of diesel with subsidy of Rs 35/ litre @Rs 350/ irrigation is given to farmers through DBT.
7. DSR method has been introduced to adapt to drought like condition for sowing of paddy. Climate resilient crop like maize and *arhar* in upland area has also been introduced as an option.
8. Green manuring with summer Moong and pre monsoon *sesbania* has been introduced to improve physical condition of soil as well as improving water holding capacity of the soil. Farmers experience is very encouraging.
9. As delay in monsoon or heavy rain at later stage of the *kharif* crop delays the *rabi* season sowing, zero tillage in wheat has been introduced which has resulted in timely sowing and uniform germination of wheat.
10. Now state government has started campaign to stop crop residue burning in field after harvesting. Mulching of straw in field has been introduced and machinery like baler, reaper cum binder is in great demand by farmers. Mulching helps in in situ moisture conservation.

5. Shortcomings in implementation of available Technologies

Managing drought is complex and even after introducing a number of interventions for the benefit of the farmers, shortcomings are bound to come and the government is in continuous endeavour to reduce the shortcomings. A number of shortcomings have been identified which the government is trying to reduce by means of better policy planning:

Poor availability of short duration seed / drought resistant seed in state. Seed producers are interested only in good yielding variety of seed as there is higher return in HY long duration variety. Seed grower are not interested in varieties like Sahbhagi,

Prabhat, Turanta which are in great demand in case of delay of monsoon or drought like situation. This results in a serious constraint for implementation of contingency plans in districts experiencing deficit rainfall.

If monsoon rain fails green manuring with *dhaincha* is also affected adversely.

Non availability of YMV resistant variety for summer moong.

Non availability of short duration Arhar variety as UPAS 120

Non availability of contingent crop *var* seed of *toria*.

High cost of micro irrigation plants

6. Recommended corrections in different stages of the adopted technologies

Promotion of seed production (breeder/ foundation / certified) of high yielding short duration varieties (less than 115 days) and medium duration varieties (125-135 days) for both direct seeding and transplanted conditions. Effective linkages and coordination among the State line departments and State Agricultural Universities is highly desirable for implementation of a successful seed production plan well in advance. Strengthening of scientific storage infrastructure is warranted. In the event of a normal season, mechanism/schemes should be put in place to absorb the difference in cost of disposal other than as seed material. Making villages self-reliant in the local seed requirement of those varieties not in the normal seed chain is imperative for increasing the resilience of the farming community.

7. Best Practices for Drought Preparedness, Monitoring, Mitigation, Response and Relief Strategies

To protect agriculture from drought there need to be long term and short term measures. In the recent past there has been paradigm shift in disaster management in the state. Now disaster management is not only relief but in broader perspective it involves preparation, mitigation, response, relief, rehabilitation and reconstruction. The disaster management perspective of agriculture sector entails preparation, mitigation,

response and relief. The following best practices are being envisaged by the state for better management of drought:

Drought Preparedness: Drought hazard mapping for drought prone districts of Bihar are being prepared and contingent crop planning for mitigating the impact of drought and creating awareness among farmers about the same. Deputation of agriculture scientist for timely advisories in case of calamities like drought. Administrative measures to ensure canal water upto the tail end of irrigation canal.

Monitoring: Drought monitoring mechanism exist with weather inputs from IMD and drought progress input from MNCFC (Mahalanobis National Crop Forecasting Center). A better monitoring mechanism is currently being implemented by the government by acquiring high resolution meteorological data and forecast from a dense network of automatic weather station and rain gauges at block and gram panchayat level.

Mitigation: Bihar Rajya Beej Nigam is setting up seed bank in which short duration varieties of rice and other suitable crops will be kept so that it could be utilized in case of need.

Relief & Response Strategies: The department has a well formulated relief and response strategy. Input subsidy is a major strategic intervention in case of crop damage due to drought. Diesel subsidy is being implemented in case of drought like situation.

12. Drought Management Strategies in Rajasthan: Best Practices

Disaster Management,

Relief & Civil Defence Dept., Jaipur (Rajasthan)

BACKGROUND:

Rajasthan is the largest state in India. It covers 10% of the country's land area and 5.67% of population, but has only 1% of water resource. 12 out of the 33 districts, which comprise 60% of the area of the State, fall within the Thar Desert. Thar is the most populous desert in the world. Despite scanty rainfall with all its variation, timing, intensity and irregularity, 64% of its population lives in this area. The rural economy of Rajasthan is governed by agriculture and livestock. Agriculture is mostly rain dependent. Pattern of rainfall is very much skewed in the State. Behavior of monsoon commands over the livelihood of people. Except for the Chambal, the 13 other rivers of the state are non-perennial. Only 30% cultivable land is under irrigation, 68% out of it is irrigated from ground water. Ground water is highly exploited and the average ground water exploitation is 138%. 198 out of the 249 Blocks of the State are in dark zone. The per capita water availability in Rajasthan is 780 cum as against a minimum requirement of 1000 cum. Significant quantity of rain water is also lost through surface run off and evaporation. Hence, it has been experienced that there is no assured irrigation and people have to resort to dry farming techniques.

Rajasthan has approx 12% of the country's cattle population which contributes significantly to the State GDP by providing major share to the rural employment. However, this sector also faces a lot of stress owing to less availability of feed and fodder due to scanty / no rains. This also leads to increased number of stray animals as the farmers are not able to conserve their live stock due to scarcity conditions. This increase of stray animals also causes considerable destruction to the standing crops.

In the six decades since the country's independence, Rajasthan has shown steady progress in many economic and human development indicators. Diversification of crop

varieties and a price policy which supported crops suitable for the agro-climatic conditions helped improving the agricultural performances. The poverty proportions reduced substantially, literacy rates improved, consumption inequalities declined, and regional disparities in economic growth decreased.

Rajasthan sought to broad base the economy by diversifying into non-agricultural sectors, especially the industrial and service sectors. Given Rajasthan's vast mineral resources and subsistence of majority of rural population on agriculture, the industrial development in Rajasthan focused on mineral-based and agro-based industries. The State industrial policies have progressively sought to exploit the mineral reserves of metallic and non-metallic minerals like zinc, lead, copper, limestone, marble, granite, gypsum, lignite, petroleum and natural gas resources. The small- scale industries have shown significant growth primarily on textile printing and dyeing, small mining leases, stone crushers, cement kilns and agro-processing units. Tourism has immense potential for employment generation in Rajasthan. Major focus has been given in promotion and development of tourism due to State's rich cultural heritage, forts and palaces, vast desert, wildlife sanctuaries, religious sanctity, traditional fairs and festivals, and folk performances. The State has also started exploring its considerable lignite, oil and gas reserves.

DROUGHT HISTORY:

Drought is almost an annual feature in Rajasthan. It's slow and quite steady. After the formation of Rajasthan State, except the years of 1959-60, 1973-74, 1975-76, 1976-77, 1990-91 & 1994-95, Rajasthan has experienced drought in some part or other with its impacts on a very large population for a much longer period.

The **rainfall pattern** in south and western Rajasthan districts has been varying from time to time but western Rajasthan invariably experiences scanty rainfall. Also 5 Districts: Banswara, in Udaipur Division and 4 others in Kota division have been receiving more than 550 MM of rainfall. Despite this, wide spread scarce conditions are prevalent in all these districts. Whereas Ganganagar & Hanumangarh receive less

than 300 mm of annual rainfall but are not under the impact of drought because of alternate and additional sources of irrigation through the canal system. Inadequate rainfall at the critical time of crop growth and flowering stage has been experienced in Rajasthan in 3 out of every 5 years. The rainy days are generally uneven across the State. The average total number of rainy days are just 34.3 in eastern Rajasthan and 16.8 in western Rajasthan.

DROUGHT MANAGEMENT STRATEGIES ADOPTED:

Government of Rajasthan has a very well defined objectively verifiable drought assessment mechanism. The declaration of scarcity and drought situation is announced by considering the agro-climatic indicators (rainfall and hydrological situation), detection of early warning signs, review and observations of the weather watch group, Girdawari (assessment of crop status) of the Kharif crops and District Governments detail report. Based on all these reports, the state government declares scarcity of areas having 50% damage to crop or more.

The State has a Disaster Management policy in place. It has a detailed Drought Management manual for ready reference for all the stakeholders and field functionaries. It has Emergency Operation Centers (EOCs) at the State as well as in all 33 districts. It updates the data regularly in the India Disaster Response Network (IDRN). It has established the State Disaster Management Authority (SDMA) and the District Disaster Management Authorities (DDMAs) and follows the guidelines of the National Disaster Management Authority (NDMA).

Government of Rajasthan adopts a multi-sector multi-dimensional and multi-stakeholders approach in managing the drought in the State. It focuses on employment generation (both short term and long term) for ensuring sustainable livelihood opportunities (with special care for vulnerable groups) by converging various development schemes, cattle conservation through fodder depots, fodder transport subsidy, cattle camps, medical aid to cattle population, etc. It also focuses on provision of drinking water by hiring private wells, repairing and installation of hand pumps,

reviving traditional water sources, transporting water through rails and tankers. It also leads to draw the crop contingency plans by adopting soil moisture conservation practices, making field crops free from weeds, adopting recommended plant protection measures, providing agriculture inputs like short duration seeds, extending training to farmers, supporting through minimum support prices to arrest distress sale. It suspends the recovery of land revenue and irrigation Cess in the drought notified areas. It converts the short term cooperative agricultural loan to medium term for the benefit of the farmers. It adopts the mitigation strategy by developing community based drought preparedness and mitigation plans by integrating the concerns of women and converging the same with various other existing schemes. A lot of emphasis is given to effective water management which include rainwater harvesting, watershed management for recharge of ground water, appropriate cropping pattern, early completion of existing projects, agro-climatic regional plans, maintenance of irrigation system, sprinkle and drip irrigation, conjunctive use of surface and ground water, reduction in evaporation, renovation of tanks, creating water consciousness in public, etc.

Government of Rajasthan also gives very high priority in the monitoring of drought management activities. High level task forces are constituted, ministers and secretaries are nominated as in-charge for relief supervisions, detailed instructions are given to the district collectors, government officials are made in-charge of activity at the village level. Public representatives at all level (even at the community level) are involved, social audits and web applications are being done for better transparency, on-line placement of budget demand and timely allotments are made for enhancing effectiveness of the programme.

OUTCOME OF EARLIER EFFORTS: MJSA

Based on the agro climatic conditions, different schemes have been initiated by state Government through different departments for improvement in water availability and land productivity. However, all these departments were independently implementing these schemes and there was a lack of convergence of efforts and

resources which was not giving the desired results. Therefore, it was felt that all these efforts should be synchronized to produce better and effective results.

Hence, it was decided to launch “ Mukhya Mantri Jal Swavlamban Abhiyaan”(Chief Minister Water Self-reliance mission) (MJSA) in the State with a view to converge various schemes and to bring them on a single platform to conserve the four waters i.e. Rainfall, Runoff, Ground water and Soil moisture up to maximum potential.

MJSA is a mission started by State Govt. on direction of Hon'ble CM to make villages self reliant in terms of water needs, a vision to find permanent solution of drinking water scarcity in Rajasthan with help of people participation.

OBJECTIVES OF “MUKHYAMANTRI JAL SWAVLAMBAN ABHIYAAN (MJSA)”

- To ensure effective implementation of water conservation and water harvesting related activities in rural areas from available financial resources (Centre, State, Corporate, Trusts and People's participation) through effective convergence
- To undertake implementation of works through people's participation and to generate awareness among villagers and beneficiaries about judicious utilization of water resources
- To prepare water budget after estimation of water availability from various available resources and requirement of water for drinking, irrigation, live stock and commercial purposes
- To identify works and proposals in consultation with local people so as to harness their traditional knowledge/practices and seek due approval of action plan in Gram Sabha (village council)
- To harvest available runoff (rain water, ground water and in situ soil moisture) in rural areas through treatment of catchments, proper utilization of available water harvesting structures, renovation of the non functional traditional water harvesting structures and creation of new water harvesting structures

- To develop land, water, forest and fauna, keeping watershed/cluster/index as a work unit for natural resource management
- To find permanent solution of drinking water scarcity by making the Village self reliant in terms of water.
- To increase the Irrigated area through water harvesting and conservation

1. SCOPE OF CAMPAIGN:

Water harvesting and conservation works are being implemented from the funds available with State Government Departments and the shortfall is being mobilized from Non Government Organizations, from Corporate Social Responsibility commitments (CSR), Peoples Participation, Non Residents Villagers Clubs (NRV Club) etc to safeguard the villages from frequent droughts by doing watershed wise water budgeting and attempt to find a permanent solution to the chronic drinking water shortage problem.

In the first phase, 3529, villages (islands of excellence) on the basis of defined priority criteria had been identified and the phase-II covered 4213 villages. In 3rd year Phase-III is covering 4240 more vulnerable villages. In all, 21000 villages of the State are likely to be benefitted under the mission. The state government shall strive to find a permanent solution to the water scarcity problem by making them self reliant in terms of water.

2. DURATION OF WORK:

The duration of “MukhyaMantri Jal Swavlamban Abhiyaan (MJSA)” is of 4 years commencing from Financial Year 2015-16.

The aim is to complete the works of Action Plan of every year by 30th June of next year i.e. before the monsoon (rainy season), so that benefits of these watershed works

start flowing to the community from the same year. Only in special conditions works are allowed to be implemented in next year after the approval of District Committee.

Generally works are being executed as per Gramin Karya Nirdeshika (GKN) or as determined by the District Committee.

3. MUKHYAMANTRI JAL SWAVLAMBAN ABHIYAN (Rajasthan Water Self-Reliant Mission):

In order to achieve the objectives of “MukhyaMantri Jal Swavlamban Abhiyaan (MJSA)”, a high level Mission has been setup under the chairmanship of Hon’ble Chief Minister at the State Level. Further, to ensure smooth implementation of the activities, a Directional Committee under the chairmanship of Chairperson, Rajasthan River Basin and Water Resources Planning Authority and a Task force under the chairmanship of Chief Secretary have also been constituted. At district level, a supervisory committee under the chairmanship of Hon’ble Minister –in charge of the respective district and an executive committee under the chairmanship of District Collector have been constituted. Similarly at Block Level, a review committee under the Chairmanship of Sub Divisional Magistrate has also been set up.

4. SANCTION OF DISTRICT ACTION PLANS

The District Mission Plan is issued by the District Collector after approval from the District Level Committee.

5. PREPARATION OF PRIORITY LIST OF VILLAGES: CRITERIA

- Villages where IWMP / other watershed Project e.g. “Four Water Concept” etc. are sanctioned
- Villages where drinking water is not potable or fluoride quantity is in excess
- Villages where drinking water was supplied by tankers during last five years

- Villages declared as famine/ drought effected during last five years
- Villages where 70 % of agriculture land is rain fed
- Adarsh villages under Chief Minister, MP, MLA & other schemes
- Villages falling under sanctioned cluster of forest department scheme
- Villages where villagers are willing to participate/contribute in this scheme

Keeping in view above criteria, the priority of villages in Gram Sabha is fixed as per marks mentioned in the table below:

Sl. No.	Details	Total marks	Marks obtained	Marks obtained	Marks obtained
1	Villages sanctioned under IWMP (09-10)	20	Sanctioned Area more than 50% of the Total Area of the Village under IWMP (20 Marks)	Up to 25 to 50 % (15 Marks)	Up to 25 % (10 Marks)
	Villages sanctioned under IWMP (10-11 & 11-12)	15	Area more than 50% (15 Marks)	Up to 25 to 50% (10 Marks)	Up to 25% (5 Marks)
2	Villages sanctioned under Four Water Concept	15	Area more than 50%	Up to 25 to 50%	Up to 25%
			(15 Marks)	(10 Marks)	(5 Marks)
3	Villages under tanker water supply for drinking water	15	Continuous for 5 years	Last 3 years	From last year
			(15 Marks)	(10 Marks)	(5 Marks)
4	Famine affected villages	10	3Years of Famine out of last 5years, specially having Famine last year	3 out of last 5 years	Famine in last year
			(10 Marks)	(5 Marks)	(3 Marks)
5	Fluoride affected villages	5	Affected villages (5 Marks)	-	-
6	Rainfed agriculture land	5	More than 70%	50 to 70%	-
			(5 Marks)	(3 Marks)	
7	Villages Sanctioned by forest department	10	Cluster on- going work from 3 years (10 Marks)	Cluster in progress current year (5 Marks)	Proposed villages (3 Marks)
8	SANSAD ADARSH Village	10	Sanctioned ADARSH Village (10 Marks)	-	-
9	Villagers willing to contribute for the works of village development plan	10	For each 1.00 lac (1 mark)		

Note: All the villages of the clusters of Micro watershed (Approx 5000 ha. area) in which first priority village exist being taken on priority & after that the whole Micro watershed /cluster having village of second priority. In similar manner, clusters are selected till approximate 10 villages are covered. It is ensured that at least one Micro watershed /cluster get sanctioned in each block.

6. FUND MANAGEMENT:

The estimate of every work is prepared after the village action plan is approved by district level committee. Then an assessment is made as to how many works can be completed from funds available under different ongoing schemes and how much funds need to be raised for other sources. Details of activities and probable schemes from which funds are being accessed as under:-

Sl. No.	Name of activity	Availability of fund	Implementing agency
1	Watershed development works such as water harvesting structures, farm ponds, contour / field bunds, CCT, deep CCT, gabion, sunken gully pit, MPT, Tanka, Johad etc.	PMKSY, IWMP, Mahatma Gandhi NREGA, National horticulture mission, Rashtriya Krishi Vikas Yojana, state fund etc.	Watershed development department, Panchayati Raj Institutions, Forest department, Agriculture department
2	River Basin Micro Irrigation tank, Check dam & Construction of New Structures for Watershed development works based on Four-Water Concept	Schemes of Irrigation, Ground-water, Watershed & Forest Department	Water Resource department, Panchayati Raj Institutions, Watershed development department, Forest Department
3	Deepening of Nalas / widening of banks and construction of series of cement check dams and Other Nala bundh	PMKSY , The State Fund , MP /MLA development fund, zila parishad schemes, voluntary organizations, CSR and institutional support	Water Resource department , Watershed development department, Panchayati Raj Institutions
4	Renovation/Rejuvenation of old water harvesting structures	PMKSY, IWMP, Mahatma Gandhi NREGA, schemes of water resource department, State fund, MP/MLA development fund, schemes of zila parishad, Voluntary organizations , CSR and institutional supports	Water resource department, Watershed department, Panchayati Raj Institutions

5	Preparation of New Micro Irrigation Schemes & Repair, Renovation& Reinforcement of minor irrigation works	PMKSY, schemes of water resource department, the state fund, MP/MLA development fund schemes of zila parishad, voluntary organizations, CSR and institutional supports	Water Resource department, Watershed department, Panchayati Raj Institutions
6	Desilting/deepening of water conservation structures like village ponds, Nadis, water tanks, Water storage structures, Percolation tanks etc.	PMKSY, the state fund, MP/MLA development fund, schemes of zila parishad, voluntary organizations , CSR and institutional supports	Water Resource department, Watershed Department, Panchayati Raj Institutions
7	Works to take maximum use of irrigation potential of created large and medium irrigation projects in region	PMKSY, State fund, MP/MLA development fund, Schemes of zila parishad, Voluntary organizations, CSR and institutional supports	Water Resource department, Panchayati Raj Institutions
8	Linkages of water sources/structures to Nalas	PMKSY, Mahatma Gandhi NREGA, Public Participation, Voluntary Organizations	Water Resource department, Gram Panchayat, Watershed department
9	Construction of Artificial structures for Ground-water recharging	PMKSY, Mahatma Gandhi NREGA, Water Resource department schemes, Ground water & Watershed, Schemes of central water resource department	Ground water, Local bodies,Water Resource department, Panchayati Raj Institutions
10	Reinforcement of drinking water sources	PMKSY, Schemes of zila parishad, PHED, Own income of gram panchayat and grants received	PHED, Panchayati Raj Institutions
11	Development works in command area of Large, medium & Minor Irrigation projects	Schemes of Command area development department	Water Resource department, Panchayati Raj Institutions, Command Area Development Department
12	Pasture development and plantation	PMKSY, Schemes operated by Forest Department	Forest department
13	Water drainage & Sanitation works in Rural Area	Panchayati Raj Institutions schemes operated by Water Resource Department	Panchayati Raj Institutions, Water Resource Department

7. STRATEGY :

1. Initially, for the first phase in year 2015, approximately 3,000 villages were planned. A total of 3,529 villages were taken up with completion of 95,793 works. Plantation work of a total of 28 lakh trees was completed.
2. Village action plan for these selected villages was prepared keeping in view the model plans for selected micro watersheds / clusters and accordingly works were executed.
3. Funds available in Central & State schemes were earmarked as per prevailing Guidelines.

On the basis of encouraging results of MJSA Phase-I and involvement of people of State at large in its activities, Government decided to launch this mission in urban area too in year 2016.

8. PROJECT IMPLEMENTING AGENCY:

Agriculture department, Rural development & Panchayati Raj department, Forest department, Water Resource department, Mahatma Gandhi Nrega scheme, Watershed development & Soil Conservation department, P.H.E.D., National Horticulture Mission, NGO's, Cooperatives, Water & Sanitation Committees, Gram Vikas Mandal (registered organizations), Ground Water Department & Department /Institutions /Organizations/Experts authorized by the District Collector.

9. WORKS BEING UNDERTAKEN IN THE CAMPAIGN:

1. Watershed (catchment) area treatment: Deep Continuous Contour Trenches (deep CCT), Continuous Contour Trenches (CCT), Staggered Trenches, Farm Ponds, Mini Percolation Tank (MPT), Sunken Gully Pit (SGPT), Earthen bund with stone pitching, Khadin, Johar, Tanka construction, Water harvesting structures, Gabion Structures, Compartment/Contour/Field Bund etc.

2. Drainage line treatment: Small Anicuts in series, Earthen check dams and Water storage structures, Mini Percolation Tank (MPT), Sunken Gully Pit (SGPT), Minor Irrigation tank etc.
3. Repair of minor irrigation work, renovation, reinforcement work, works to take maximum use of large and medium irrigation projects constructed in the region and works for linkage of water sources/ structures.
4. Increasing the capacity of water storage structures: - by Repair and Revitalization/ Restoration, Rejuvenation, Deepening of Nallas by desilting and widening as per requirement, bank stabilizations and peripheral bund.
5. Reinforcement of water sources, Recharging of wells & Tube wells.
6. Pasture development & plantation.
7. To Increase Agricultural Productivity by promoting advanced methods of cropping & horticulture (Drip, Solar pump etc) & to promote commercial farming by crop rotation to take maximum output of Rabi, Kharif & Ziad crops.

10. SPECIAL POWERS TO DISTRICT COLLECTOR FOR IMPLEMENTATION OF MISSION:

- To formulate action plan for “Mukhya Mantri Jal Swavlamban Abhiyan” in the district and effect convergence of different schemes for implementation, monitoring & evaluation.
- To mobilise the shortfall in resources and generate support from NGO's, CSR, NRV & other Bhamashah's (donors)
- Competent Authority for Sanctions (Technical, Administrative and Financial sanction) of works

11. STEPS FOR PREPARATION OF DISTRICT PLAN OF “Mukhya Mantri Jal Swavlamban Abhiyan”:

1. Village Work Plan is approved by the Gram Sabha & submitted to Block level committee by the Departmental representatives
2. Block level Plan duly scrutinized by the Block Committee under the chairmanship of Sub Divisional Officer/Block Development Officer forwards the Plan to District level
3. After approval of District Plan & issuance of Administrative sanction, concerned department issues Technical sanction
4. Financial Sanction at district level is issued within 15 days and directions are issued to executing agency for commencement of work immediately.
5. Apart from executive agency, District Collector appoints responsible officers at Gram Panchayat level/Cluster level for supervision and monitoring of execution works within time. These officers are responsible for uploading progress reports regularly on the online portal.
6. A meeting at least once in a month at District Level for monitoring of progress under the chairmanship of Collector is organised. All Sub Divisional Officers and concerned Departmental officers have to participate in this meeting.
7. Review of works and timely payment of executed works is ensured alongwith adjustment of funds and financial progress.

Department wise & Gram Panchayat wise progress, problems & solutions are submitted to District level monitoring & evaluation committee under Chairmanship of Minister in-charge of District.

12. PARTICIPATION OF CSR/NGO/TRUST etc:

The Mission envisages a very significant contribution from the civil society to fulfill the likely gap in available financial resources particularly from the Corporate

Sector, Non-Governmental Organizations, Religious Trusts, and Individual Groups. These contributions can be in the following forms:

1. Corporate Sector, Non- Governmental Organizations & Religious Trusts have full freedom to adopt any village as a whole or works of a particular village or execute works themselves under technical guidance of department.
2. In addition to above, Corporate Sector can contribute resources to fund the gaps in the proposed village plan.

13. PREPARATION OF WATER BUDGET:

- Estimation of availability of Run-off Water depending upon the type of soil, slope of land and utilization of land surface.
- Assessment of demand of village (for Human, Livestock, Industries & agriculture use).
- Assessment of Capacity of existing Water Harvesting Structures in village and proposed Water Harvesting Structures.

After the above exercise, estimation of surplus/shortfall of water of villages of the catchment/ watershed in respect of run- off water coming from other catchment or going out of village to other catchment is to be done and detailed water flow network is to be prepared at village, Block and District level.

14. PUBLIC AWARENESS FOR MISSION:

- **State Level Orientation Workshop:** Orientation of Ministers, Chief Secretary, Principal Secretary, Divisional Commissioner, Head of the departments, MLA's, District Collector's & Superintendent of Police, Project Manager's (Watershed) etc. under the Chairmanship of Hon'ble Chief minister.
- Divisional level orientation workshop
- District level orientation workshop

- Block level orientation workshop
- Orientation of CSR, Industrialists, NRI, NRV, NGO's etc.
- Orientation of owners of JCB, Pockland, Tractor & other Earth Moving Machines.
- Orientation of Village level/Gram Panchayat level workshop.
- Nukkad Natak /Puppet Show
- JAL Pad - Yatra
- Religious Saints & Gurus to convey the messages related to water conservation
- Advertisements through different media like Doordarshan & newspaper for publicity
- To encourage non-resident people of state & NRV who works in other District/State for funding in the Mission by using techniques like Twitter, Facebook, Whatsapp.

A Public awareness campaign in Gram Sabha is to be conducted by Gram Panchayat & Watershed department. Funding for this campaign is to be met out from available funds under IEC in Schemes of Swatch Bharat Abhiyan (SBA), IWMP, Agriculture, Water Resources and Panchayati Raj department. In this Campaign, villagers are to be sensitized about the objectives of the mission.

15. EVALUATION AND PROGRESS REVIEW:

Monitoring is based on GIS technique on real time basis in “Mukhya Mantri Jal Swavlamban Abhiyan”. For this, GIS Portal of Information & technology is used. Latitude & longitude of all water conservation works executed are taken in the smart mobile phone and the same are uploaded on Bhuvan portal (Srishti-Drishti) on real time basis.

Along with all other information, Village Work Plan, Base Line survey, Cost of Work, Present Condition, Working Agency & Department, Progress Report are being uploaded on website. This work is being done with the help of Information &

technology department. Separate website has been created for “Mukhya Mantri Jal Swavlamban Abhiyan” where monitoring of works is being done online.

Nodal department prepares the progress report by getting the information from block/district level through MIS System and compilation is done at district level.

16. IMPACT INDICATORS:

- Increase in irrigated area under agriculture (Agriculture & Revenue Department).
- Changes in the cropping pattern (Agriculture & Revenue Department).
- Reduction in the water supply from external water sources to the village (Public Health & Engineering Department).
- Reduction in occurrence of Famine (Revenue Department).
- Increase in number of Agro forestry, Horticulture plants (Agriculture & Horticulture Department).
- Timely Payment of Agriculture Loan/ Kisan card (Cooperative Department).
- Improvement in quality of under-ground water (Public Health & Engineering Department)
- Reduction in seasonal migration of Cattle (Animal Husbandry department/ Sheep & wool)

17. EXPECTED OUTCOME:

- Availability of surface flow in the main stream of watershed & presence of surface flow up to April-May in small streams.
- At least 40 % Rain-fed area would be irrigated.
- Reduction in suspended sediments in flowing water of main streams.
- Drinking water needs are fulfilled by the groundwater & water would be available for irrigation of perennial plants in summer also.

- Emergence of self water reliant village (free from tanker supply/ free from Famine & permanent solution of water)
- Increase in ground water level and reduction in depletion of ground water level
- Increase in irrigated areas
- Change in the cropping pattern
- Stability in availability of drinking water
- “Mukhya Mantri Jal Swavlamban Abhiyan” is a time bound mission and a time-line has been set for timely execution of the proposed works.

18. WORKS TAKEN UP AND PROGRESS SO FAR:

1. The details of MJSA Rural, Phase I to III are as under :-

Year 2015-16

Phase-I : No of villages approached 3529
 No of works completed 95793
 Plantation 28 lakh trees

Year 2016-17

Phase-II : No of villages approached 4213
 No of works completed 129484
 Plantation 60 lakh trees

Year 2017-18

Phase-III :No of villages planned 4240
 No of works planned 1.50 lakh approx.
 Phase III campaign inaugurated on 9th, 15th Dec. 2017 & 20th Jan.18

Mukhya Mantri Jal Swavlamban Abhiyaan (MJSA) Urban

Works taken in MJSA (Urban) Phase-I (Nov. 2016)

Works taken up in Phase-I (66 towns, 2 from each district).

- Repair and restoration of Bawaris and step wells.
- Productive use of rain water by enhancing ground water recharge through Roof Top Rain Water Harvesting Structures (RTWHS) over all Government buildings with roof top area 300 sqm & more.
- Afforestation in the city area as an eco-friendly measure for improved and green landscape of the town.

Works taken in MJSA(Urban) Phase-II (Jan.2018)

Works in Phase-II taken in all the 191 towns of the State

- In addition to works taken in MJSA(Urban) Phase-I, following one more activity was added in Phase-II
 - Identification of areas prone to storm water stagnation in municipal area and Action Plan for remedial measures in the cities.

Progress of works of both phases of MJSA(Urban)

	Ph-I	Ph-II	G. Total
• RTWHS	1452	1482	2934
• Bawaris	259	214	473
• Afforestation	71	70	141
Grand Total	1782	1766	3548
Cost of Works-	95 Cr.	120 Cr.	215 Cr

- Total **plantation** done under MJSA(U) ph I :
 - By forest department - 304599 (O&M by forest deptt.)
 - By ULBs - 217143 (O&M by ULBs)
 - Total - 521742 Plants**

Total **plantation** done under MJSA (U) ph-I I : **2.5 lacs** {1.5 Lacs(Forest Dept.)+1.0 Lacs (ULB) }

Preparation and proposals of **water logged areas**:

- Prefeasibility reports of 60 towns (having 196 spots) having waterlogged area identified - costing approx. 413.62 Cr.

Funds from various departments and MPLAD / MLALAD and public contribution were arranged for MJSA phase-I & II. Approx. 1710 Crores were available for Phase-I with major contributions from MGNREGS (411 Cr), MJSA Untied Fund (540 Cr), Crowd Funding (26 Cr.) and Watershed Department (565 Cr). For Phase-II a total of approx. 1614 Crores were arranged with major stakeholders as MJSA Untied Fund (668 Cr), IWMP (185 Cr), MGNREGS (224 Cr), PMKSY (102 Cr), Crowd Funding (51 Cr) and MLALAD contributed more than 32 Crores.

19. IMPACT ASSESSMENT:

The targeted results of the village work plan under the mission are being reviewed keeping in view the following indicators:

Main indicators for evaluation (and responsible departments) and results from MJSA Phase-I are as under:

- **SUPPLY - SIDE INDICATORS**

- (i) Additional Sustainable Storage Creation – **4,516 MCFT**
- (ii) Additional Interception of Precipitation - **11,170 MCFT.**
- (iii) Positive impact on Groundwater
 - Average rise in non-Desert Districts - **4.66 FT**
 - Nowhere negative trend observed

- **DEMAND SIDE INDICATORS**

- (i) Reduction in Tanker Trips - **56.13 %.**
- (ii) Defunct Hand Pumps Revival - **63.64 %**
- (iii) Lean Season Crop Area Enhancement - **46,879 HA.**
- (iv) Lean Season Orchard Area Enhancement - **323 HA.**
- (v) Enhancement in Tube & Open Wells Functioning - **22%.**
- (vi) Increase in Green Cover - **3678 HA.**

13. Drought Management Strategies – Best Practices

Government of Telangana

1. Back ground:

Telangana state is the 29th State of India and located in semi-arid region with rainfall i.e., south west monsoon, as major source of water. The major occupation for two-third of the population is agriculture. The important Krishna and Godavari rivers flow through the state from West to East. Out of the total net cropped area of 41.75 lakh ha, 14.86 lakh ha is net irrigated area and 64% of the area (26.89 lakh Ha) is under rain fed cultivation. The area under canal irrigation is 7.60 per cent (*Source: DES*)

Rainfall: Agriculture is dependent on rainfall and its production depends upon the distribution of rainfall. The influence of South-West monsoon is predominant. South-West Monsoon (79%) is spread over the period from June to September, North-East Monsoon (14%) from October to December and the rest 7% rainfall is received during the winter and summer months. The rainfall is seasonal in character with short rainy season of 3 to 4 months and the state experiences dry conditions for 8 to 9 months in various parts and more so in southern parts of the state. Telangana receives a normal rainfall of 905.3 mm in a year. The season wise breakup is as follows.

Sl.No	Season	Rainfall received (mm)
1	South – West Monsoon	713.5
2	North – East Monsoon	129.5
3	Winter Season	11.5
3	Hot Weather	50.8
	Total	905.3

Source: Agricultural Statistics at a Glance, Telangana 2015-16, DES.

Agro climatic zones: Based on climatic parameters i.e. Rainfall, Soils and cropping pattern etc., the State is divided into 3 Agro-climatic zones, i.e. Northern,

Central, Southern. The agricultural planning for each zone is supported with the research and recommendations of Regional Agricultural Research Stations of PJTSAU setup within each zone.

History of Drought for the past Two Decades: An analysis of the past two decades (Table .1) reveal that Telangana faced the woes of drought and impact of climate change .Out of the 20 years, during seven (7) years the State received normal rainfall and in the remaining 13 years drought was declared which works out to 65%. The intensity of drought was maximum during 2002-03 when 446 mandals in all the 9 erstwhile districts were declared as drought affected. Further 1997-98 (433 mandals), 2009-10 (442 mandals), 2011-12 (418 mandals) were also severe drought years. During 2005-06, 2007-08 and 2008-09 there was no incidence of drought. Severe drought was prevalent during 2009-10 and 2011-12. There was a period of good rainfall during 2010-11, 2014-15 and 2016-17 with mild drought during 2012-13 (16 mandals in 2 districts) and during 2013-14 (6 mandals in 3 districts).

2 & 3. Drought management strategies adopted & Implementation of Technology:

- Based on the forecast of monsoon, with the objective of minimizing the impact of the vagaries of weather conditions and for the arrangement of required alternate crop seed and varieties that can be sown in time in case of delayed monsoon and as per the suggestions of CRIDA, KVKs, DAATT centers and PJTSAU all the District DAOs will prepare the district wise, crop wise contingency plans for 3 periods i.e., if the rains are not received till 15th July, till 31st July and till 15th August in the month of May. Accordingly Updated District-wise Crop contingency plans are prepared and kept ready and available with extension functionaries at District/ Mandal levels.
- Quality seeds of short duration varieties will be placed well in advance for immediate distribution on 33% to 50% subsidy. Accordingly, sufficient provision is made for drought resilient varieties of seeds at appropriate hubs.

- The Department is also organizing Campaigns in each and every Gram Panchayat during Mana Telangana Mana Vyavasayam (MT-MV) on importance of Cultivation of Irrigated /Dry (ID) crops such as maize, greengram, blackgram, redgram and groundnut, instead of the usual paddy, to avoid income and crop losses, and also to increase the area of short duration crops and alternate varieties. Awareness on cultivation of short duration rather than long duration varieties of Paddy.
- Close linkage is established with IMD to disseminate the local specified weather report through Mandal / Village level Officials to prepare for adverse seasonal conditions well in advance.
- SMS through Mobiles is regularly sent to farmers regarding the indication of calamity and mitigation measures to be taken, field level functionaries and local representatives for better management of adverse situation.
- Control rooms will be opened in the offices of the District Agriculture Officers and responsible persons will be made in – charge providing help line numbers for the farmers to contact in adverse seasonal conditions.

Interventions

To mitigate the drought conditions in the state, apart from preparation of contingency plans and supply of quality seed of alternative crops/short duration varieties, the following interventions shall be taken up by the department:

- Propaganda about the sowings based on cumulative rainfall received (50-60 mm in red soils and 60-70 mm in black soils), through print and electronic media.
- ZREAC (Zonal Research and Extension Advisory Council) meetings are conducted in the agro-climatic zones covering all the districts during *kharif* and *rabi* and suggested contingency crop plan based on the rainfall pattern.
- Suggestions are given to cultivate drought tolerant crops like redgram, castor and pearl millet where ever needed.

- Joint field visits of the scientists and Agricultural Dept. officials in different agricultural divisions to suggest measures accordingly.
- Preparation for extended monsoon period to enhance the area and production of pulses and
- Oil seeds.
- Direct seeding and alternate wetting and drying to be given top priority in cultivation of Paddy.
- Promotion of practice of Dead Furrow
- Crop diversification, from cotton to millets and pulse crops.
- Green manure crop preceding paddy
- Adoption of foliar sprays of nutrients Urea / DAP 2% or 13:0:45/19:19:19: 1% during drought / dry spells & immediately after rains at weekly intervals to rejuvenate rainfed crops as booster dose.
- Inter/ mixed cropping using short duration varieties

Suggestions are given on **Drought Mitigation Measures** such as adoption of castor + red gram (1:1) intercropping; inter cultivation, 2% urea spray, sucking pest management. And also to adopt paired row system along with conservation furrows in soybean + pigeon pea (4:2) ratio.

- One or two life saving irrigations during critical periods for cotton, maize, castor and red gram from bore wells or farm ponds.
- Percolation tanks for ground water recharge.
- Farmers were Encouraged to have insurance under PMFBY to their crop so that they get relief in the eventuality of calamity.
- Video conference review with DAATTC, KVKs and Dept. of Agriculture officials by Hon'ble Minister of Agriculture, APC & Principal Secretary and Commissioner of agriculture at regular intervals and as and when required.

- Organizing training program on contingency crop plan for farmers through Farmer Training Centers of the state

ADMINISTRATIVE MEASURES:

- Re-scheduling of Agriculture Term Loans, Crop Loans as well as other Short Term loans based on severity of the crop
- Granting of new term loans for financing economic support schemes, agriculture and allied activities; Cottage and Rural Industries, etc., to generate incremental income and employment to landless poor, agricultural labour, small and marginal farmers and other weaker sections;
- The agricultural extension machinery shall take steps to educate and advise suitably for betterment of farmers.

4. Impact of implemented technology in minimizing losses & improve coping of capacity of the community:

During the drought years, all the necessary measures are taken to mitigate the drought effect by adopting the technology/practices as mentioned above and the farmers utilized the benefits, particularly seed supply on subsidy is done on a large scale to ease the burden of farmers. The services of PJTSAU and IMD are being utilized fully in supporting the farmers. Two success stories of 2017 are narrated below.

SUCCESS STORIES

1. Farm Ponds for Supplemental/ Life saving Irrigation: under PMKSY

Farmer Name: **Srinivas Reddy**, Village : **Mallapur**, Mandal: **Midgil**, Dt: **Mahbubnagar**



Though Midgil is generally a drought affected mandal, this farmer could get yield of 12 qt of Ground nut per acre by utilising the water from this farm pond, during last Rabi.

2. Alternate wetting and Drying in Paddy:



Field water tube

Farmer Name: **S.Mahipal Reddy**, Village: **Guru kunta**, Mandal: **Navabpeta**,
Dt: **Mahbubnagar**

Since Nawabpeta Mandal is prone to Drought continuously, the above farmer by adopting **Alternate Wetting and Drying** method in Paddy crop could get normal yields by making judicious use of irrigation water. Thus he could save 20-30% of water. The farmer used the 'field water tube' ('pani pipe') to monitor the water depth on the field in his words, After irrigation, the water depth will gradually decrease. When the water level has dropped to about 15 cm below the surface of the soil, irrigation should be applied to re-flood the field to a depth of about 5 cm. From one week before to a week after flowering, the field should be kept flooded, topping up to a depth of 5 cm as needed. After flowering, during grain filling and ripening, the water level can be allowed to drop again to 15 cm below the soil surface before re-irrigation.

5. Short comings in implementation of available Technology if any:

- SMS alerts about weather forecasts are being sent to farmers but the technology is suitable for smart mobile phones.
- SMS alerts must be communicated in local language.
- Instead of generalized SMS, the alerts may be tailored for location specific situations.
- The present assessment of Drought in terms of Mandatory and Impact indicators is difficult to correlate and to arrive at the final data regarding declaration of drought. Need to evaluate the easy and simple parameters to assess the drought.

6. Recommendations for improvement/correction of the available technology/strategy:

- Research needs to be focused on evolving better Drought resilient varieties and Drought mitigation techniques.

- SMS alerts should be location and crop specific technique duly correlating with the weather parameters.
- Surface run off techniques to conserve more moisture and ground water recharge in a better way need to be developed.

7. Best practices in Drought Preparedness, Monitoring, Mitigation, Response and relief strategies:

Telangana state has already initiated several programs for guarding the state from drought hazards by development of irrigation projects and increase the capacity of surface water resources cover through “**Mission Kakatiya**”. The State aims to increase forest cover through the gigantic program “**Telanganaku Haritha Haram**”. However, there is a need to pay constant attention to address the challenge of drought. Seasonal weather forecast at mandal and Village level is the need of the hour for appropriate agricultural planning. Efforts need to be strengthened to provide these forecasts well in advance by IMD.

14. Drought Proofing of Vulnerable Districts

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Introduction

Drought is recurring phenomena in the country. During the last 16 years, 9 years recorded below normal rainfall (i.e less than 96 percent of normal rainfall) during the *kharif* season. Five years out of these 16 years are categorized as deficient rainfall years (less than 90% of average *kharif* rainfall). The number of below normal or deficient years is comparatively higher compared with the period of 1985-2000. At the district or state level, few states in southern and western India have also recorded deficient or scanty rains during the *kharif* season resulting in decline of production in not only *kharif* season but also *rabi* season (residual moisture dependent areas). Further, hydrological drought was also visible in river basins of Krishna and Cauvery leading decline in canal irrigated area (non availability/limited availability/ delayed availability of water in reservoirs). The phenomena has become more of regular feature than aberration. The events lead to declaration of drought (particularly agriculture drought) and have a strong bearing on the production of nutritious cereals, oilseeds and pulses at a national level and also on cereals including paddy at district/ state level.

The agricultural drought could be due to insufficient seasonal rainfall, improper distribution of rainfall, lack of rainfall for a prolonged period, inadequate infrastructure for storing the available rainfall, poor soil resource base. The scenario is more exacerbated by cultivation of unsuitable crops. Agriculture drought could happen during any part of the crop growing season and is noticed only when it persists for longer period. Higher rainfall zones could also be experiencing agriculture drought due to long dry spell.

In this backdrop, when a district is declared drought affected, respective state governments affected states seek compensation from federal government year after year.

New initiatives

The Drought Management Division of Ministry of Agriculture and Farmers Welfare, Govt of India, made anew initiative to identify and implement suitable measures for agriculture and allied sectors with a view to withstand recurring droughts. As a pilot initiative, 24 districts spread over Karnataka (16), Andhra Pradesh (4) and Rajasthan (4) were identified to develop drought proofing action plans. These 24 districts were identified based on declaration of drought by respective states considering frequency of droughts during last 15 years. and the task has been entrusted to ICAR-CRIDA.

Process of Drought Proofing Action Plan preparation:

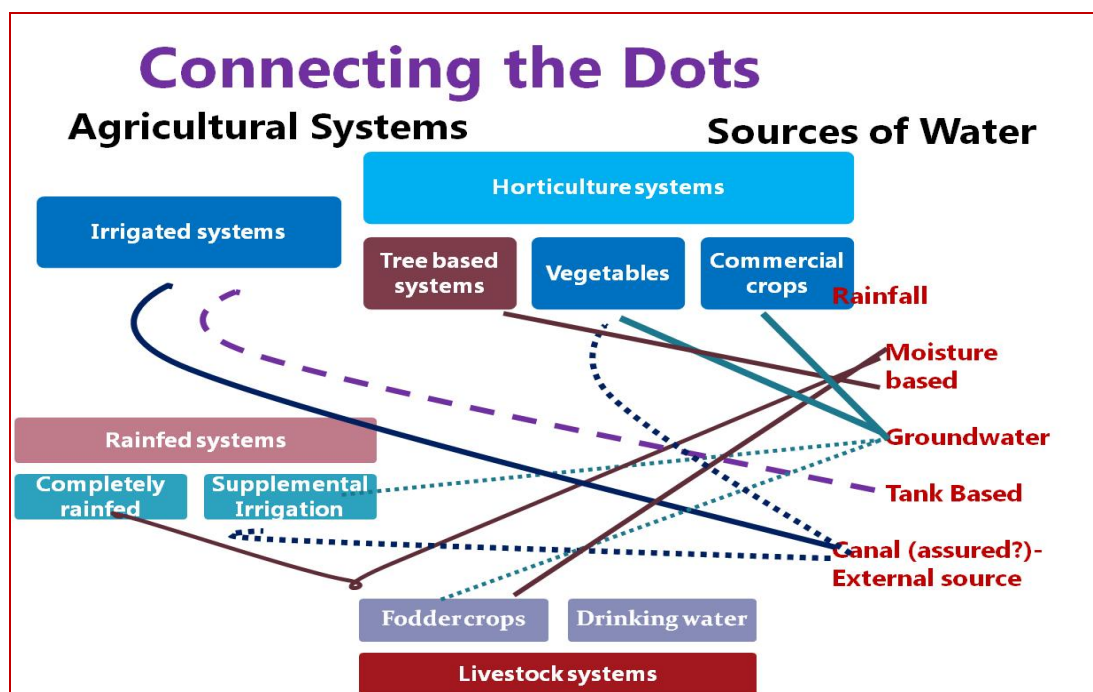
Essentially the action plan needs to identify suitable interventions after thorough assessment of resources (both internal and external) Available *vis a vis* with Prevailing Farming Systems. The scale of such study could be district/ block/ basin. In the present imitative district is chosen as unit. However, considering large variability in rain fed regions, block/taluq has been taken as unit for planning purpose in the study to account for variability in available resources and make use of finer resolution of data available for planning purpose. Once the plans are developed at block/taluq level, they are being aggregated for each district.

The plan process needs to understand the systems prevailing in the block/taluq and to identify the dependency of one over other and to link the systems very effectively to develop a sustainable plan which can take account of resources and developing systems matching o the resources. The process of plan development becomes complex when external resources are available but in plenty and when

everybody views for same resource and unknowingly clamoring for systems of heavy resource use.

If available rainfall is more than the systems requirement, management of available resource is main option and one need not depend on external resources. By suitable planning it is easy to sustain kharif season. It is also possible to ensure assured rabi cropping season. The scenario is more visible in high rainfall areas and suitable interventions would depend on water conservation systems, reuse, better inputs and improved management practices

On the other, if available rainfall is less than the systems requirement, management of all available resources becomes important and one needs to consider systems perspective, efficiency measures, priority for systems etc. The governance issues also a play a mjr role and such plan would be sustainable with active participation of all stake holders.



Hence, the drought proofing plan process consists of Assessments are made for

- ✚ Dependable rainfall/ Effective rainfall, Crop water requirements for all crops
- ✚ Potential of excess water (runoff) for *in-situ/ex-situ* conservation
- ✚ Need for additional water requirement and sources of water available

- ✚ Runoff availability and surface water availability (through canals) is considered for supplementation.
- ✚ Groundwater to be considered only if the extraction less than 50% of net availability

If no resources of external water are available,

- ❖ land and soil management practices for converting available rainfall to more effective rainfall
- ❖ change of cropping pattern
- ❖ drought resistant varieties are considered
- ❖ dissuading cultivation in *summer* and *rabi* season by suitable reduction in cropped areas
- ❖ adoption of improved management practices
- ❖ promotion of crop insurance as safety mechanism
- ❖ adoption of ground water recharge systems
- ✚ Sustainable use of groundwater is considered to enhance its availability over a years
- ✚ Dissuading cultivation of high water consuming crops
- ✚ Promotion of improved water application methods (micro irrigation systems) for groundwater use
- ✚ Priority for bridging the gap between potential created and utilized in canal systems
- ✚ Saving of water by practicing irrigated dry crops in canal commands
- ✚ Additional water accrued through savings to be made available for rain fed areas (with in district or neighboring districts which are hydrologically connected)

Strategy for drought proofing in the district :

In order to identify the impact of deficient rainfall on each crop grown in the block/ taluq, a qualitative assessment is for each crop based on the crop growing conditions. Few examples are given below. If vulnerability to deficient rainfall is high among two crops, priority would be given to those crops which occupy higher cultivated area in the block/taluq.

Prioritized systems for intervention (To cover all combination of systems prevailing in the area)

Sl. No	System -Irrigated (canal/ tank / lift irrigation / ground water) based) and Rainfed	Rainfall zone (low/medium/ high)	Soil Depth (shallow/ medium/ deep)	Season	Crops (including horticultural ones)	Vulnerability to drought (0-100 scale)	Priority (1,2,3 etc)
1	Canal	Low	Medium	Kharif	Maize	Medium	3
2	Rainfed	Low	Medium	Kharif	Cotton	High	1
3	Rainfed	Low	Medium	Kharif	Maize	High	2
4	Rainfed	Low	Medium	Kharif	Green gram	High	1

Prioritized options for drought proofing of various systems are under development for each block/ district as given below and a suitable budget estimates are made covering few years.

Sl. No	Theme	Options	Short / Medium / Long term	Priority
1.	Crop based	Promotion of short duration drought resistant varieties		
2		Crop diversification- reducing area under high water consuming crops		
3	Watershed based	Enhancing the capability of soils to store available rainfall efficiently through water conservation measures		
4		Promotion of new technologies for soil management		
5	Water management based	Efficient use of available local surface water resources during kharif for critical irrigation purposes through additional infrastructure development		
6		Better use of ground water through improved application systems		
7		Making additional water available through canals from reservoirs through transfer of water from sub basins		
8		Making additional water available through canals from reservoirs through transfer of water through river linkages (i.e from one basin to other basin)		
9		Bridging the gap between potential created & utilized in surface water systems i.e for canals mainly		
10		Bridging the gap between potential created & utilized in ground water systems		
11		Others		

Summary

The Government of India made a new initiative to drought proof the vulnerable rainfed districts often prone for droughts by enhancing the infrastructure and other related interventions. In the first phase, plans for 24 districts which are drought affected by more than 65% time during last 15 years are chosen and a district wise plans are being developed in a bottom up approach. The line departments of agriculture, horticulture, livestock, irrigation, ground water, rural development and disaster management departments are involved in the process and the whole plan development process is coordinated by ICAR-CRIDA.

15. Drought Management – Impact On Children And Women – A Time For Introspection.

Disaster Risk Reduction Section,

UNICEF- India Country Office, New Delhi.

1. Background

In May 2016, the Supreme Court of India took strong exception to the lukewarm approach of many State Governments in declaring drought and in its management (with exception being Karnataka). Based on a Public Interest Litigation, the Supreme Court of India directed Union Government to revise the drought management manual before the end of 2016, giving due weight age to the four indicators of drought with fixed determinants. These indicators were rainfall, storage water level in reservoirs, surface water and ground water levels, and sowing and crop conditions. It also directed the states and the Centre to use technology for timely assessment of drought conditions. The Supreme Court observed that a delayed declaration of a state of drought adversely affects the people, particularly women and children, and needlessly postpones the required assistance. The delay in responding to the situation caused further deprivation of the vulnerable communities, especially infants, children and women.

According to the Ministry of Agriculture and Farmers Welfare, about 24 districts in 3 States (Karnataka -16, Rajasthan and Andhra Pradesh 4 each) have experienced 10 droughts between 2001 and 2015. The states have been directed to prepare Drought Proofing plan. The process is underway in these states.

2. UNICEF study:

Against the background of this repetitive drought and drought-like situation in many states of India over the previous few years, UNICEF's India Country Office sought to improve its first-hand understanding of the direct and indirect impact of droughts on children and women and the Government programmes to lessen the

negative impact. A rapid drought impact assessment was therefore carried out in nine states¹, with the further aim of providing insights into drought management practices and their effectiveness, and to identify UNICEF's role in supporting efforts to achieve longer term climate and disaster resilience. A contextual analysis was done of drought and drought like situation over the past three to five drought years explaining its impact on women and children within the overall build-up of stress due to various factors like climate variability, unsustainable development decisions, and environmental degradation.

Table 1 State wise Coverage

States	Districts Covered	Villages covered under Rapid DIA	Additional villages covered under Nutrition Assessment	Total
Uttar Pradesh	5	24	0	24
Maharashtra	2	12	0	12
Bihar	4	19	17	36
Madhya Pradesh	4	16	0	16
Chhattisgarh	3	17	13	30
Telangana	2	9	18	27
Rajasthan	2	8	17	25
Jharkhand	4	5	0	5
Odisha	2	8	0	8
Total	28	118	65	183

The assessment covered 183 villages in 28 districts² of nine states affected by drought.

3. Sampling method

Purposive Sampling Method was adopted for the selection of states, districts, villages and households for this assessment. While the focus states were decided by the UNICEF India Country Office in Delhi, the district selection was finalized by UNICEF

¹Uttar Pradesh, Maharashtra, Bihar, Madhya Pradesh, Chhattisgarh, Telangana, Rajasthan, Jharkhand, and Odisha; in the sequence of mission start dates.

² Refer to Annexe 2: List of sample districts and villages. This includes the villages covered under the Nutrition Assessment.

State Offices in consultation with the government and other stakeholders. The selection of villages was carried out in discussion with the officials at the district-level.

For the qualitative assessment, the teams spent one day per village to survey at least 5 to 10 households, conduct three Focus Group Discussions (FGDs) and three Key Informant Interviews per village. The selection of households was made in consultation with village-level

PRI functionaries as well as local NGOs and authorities, so that the socio-economically under privileged households would essentially be covered. Time was major constraint to the study and the focus was to get information from the community during the troubled times.

4. Main Findings:

4.1 Acute water stress

- a. Water Insecurity:** Water scarcity was severe in more than 95 per cent of the 183 drought-affected villages assessed.
- b. Water scarcity:** Acute water scarcity had a bearing on the functioning of schools (scarcity of drinking water), hospitals (several PHCS stopped functioning), AWC centers, and NRCs.
- c. Water Quality:** Drinking water was mostly sourced from bore wells that had more than permissible levels of fluoride, nitrate, calcium and other impurities.

4.2 Food insecurity

- a. Nearly 80 per cent of the farming households in all the 28 districts covered under the study were struggling to cope due to depletion of the food basket:
 - i. For almost 85 per cent of the families, the Public Distribution System (PDS) became the main source of food grains and almost 100 per cent of families in Maharashtra relied solely on the supply of wheat and rice from the PDS for survival.

- ii. Pulses and vegetables virtually disappeared from the plates of 60 per cent of the families and nearly 90 per cent of the people faced severe food shortage from January to June 2016.
- b. The majority of the people cited MGNREGA as the only support for their livelihood.

4.3 Nutrition insecurity

- a. The prevalence of Global Acute Malnutrition (GAM) in Chhattisgarh and Bihar exceeded the critical stage. The prevalence of stunting in children aged 6 to 59 months was found to be very high in Bihar, Chhattisgarh, Rajasthan and Telangana.
- b. Wasted non-pregnant mothers were around 57.6 per cent in Bihar, 55 per cent in Rajasthan, 40.9 per cent in Chhattisgarh and 35.3 per cent in Telangana. Severely wasted mothers were highest in Rajasthan (19.7 percent), followed by Bihar (17.4 percent), Telangana (11.5 percent) and Chhattisgarh (8.7 percent).

4.4 Livelihood insecurity

- a. Subsistence farming, which supported nearly 67 per cent of the assessed small and marginal households, was severely affected due to successive years of drought.
- b. Forest drought led to reduced timber and non-timber forest produce availability in Chhattisgarh and Odisha, as well as limited fodder for cattle resulting in distress sale of livestock as seen in all the states visited.
- c. Distress migration was reported from across all the states.

4.5 Education insecurity

- a. Attendance at schools fluctuated as children were required to spend time in supporting families, either in fetching water, herding cattle or tending to younger siblings and the elderly in the absence of their parents.

- b. Several states started summer school and extended mid-day meals to support children and prevent dropout and migration.

4.6 Protection risks

- a. Young children and elderly were left behind in the villages as more and more adults migrated in the states of Maharashtra and Odisha.
- b. The incidence of child labour increased as children were required to support their family incomes.
- c. Cases of trafficking (Odisha) and child marriages (Maharashtra and Telangana) were identified and according to locals it increased during the drought period.

5. Best Practices by Union Governments and State Governments

Drought mitigation requires long-term policy action and course corrections from unsustainable approach in the past by stakeholders (agriculture sector, water users, and by institutions), who manage ecosystems like forests, wetlands, rivers, etc. The assessment revealed that its impact can be significantly reduced in the short term by improving governance system that anticipates the challenge and takes timely, planned and organized action to manage the consequences. The central and state governments have initiated several proactive measures, both short and long-term. Some of the effective practices are listed below:

- a. The Ministry of Water Resources has a nationwide campaign named ‘Jal Kranti Abhiyan’ (Water Movement Initiative) in 2015 wherein a village with acute water scarcity from each of the 672 districts was selected as ‘Jal Gram’. The initiative aims at converting one water scarce village in each district of the country into a water surplus village through a holistic and integrated approach that adopts conservation techniques.
- b. A DRR Roadmap is being implemented in Bihar in line with provisions of the Sendai Framework for Disaster Risk Reduction with technical support from UNICEF. The state has adopted drought Standard Operating Procedures (SOPs),

along with progressive indicators for early detection of drought. A long-term vision document (Seven Resolves) published, envisaging 'clean drinking water and toilets in every home'.

- c. The government of Chhattisgarh mobilised additional resources for drought relief by pooling funds from the Compensatory Afforestation Management and Planning Authority (CAMPA), the Mining Department and various Corporate Social Responsibility (CSR) departments for the construction or restoration of water harvesting structures.
- d. Jharkhand has drafted a State Water Policy prioritizing ecology and drinking water needs. It emphasizes water conservation through Watershed Management in 80 per cent of the state area which is drought prone.
- e. A convergent Pradhan Mantri Krishi Vikas Yojana (National Agriculture Development Scheme) is implemented in Madhya Pradesh with a vision of extending irrigation coverage to small farmers (Har khet ko pani) with improved irrigation efficiency (more crop per drop).
- f. Maharashtra prepared an early scarcity plan wherein every surface water source was monitored, tapped and managed for drinking water supply during drought (despite the absence of a district contingency plan). UNICEF in Maharashtra worked with the Ground Water Survey and Development Agency (GSDA) to develop a Drought Prediction Tool kit, to forecast outcomes such as cropping and irrigation intensities based on annual rainfall and summer water levels, enabling the planning of mitigation work.
- g. In Odisha, Pani Panchayat (an act to provide for farmers' participation in the management of irrigation system) has emerged as an effective mode of community-based surface and ground water management. Roles have been assigned to the community and the Panchayati Raj Institutions (PRIs) for developing drought management plans.
- h. Rajasthan has launched a program named 'Mukhyamantri Jal Swavalamban Abhiyan' with the objective of conserving and harvesting rainwater to make villages self-reliant even during drought periods by bringing convergence to different water

conservation projects – rainfall, runoff, groundwater and soil moisture to ensure water self-sufficiency of villages. About 3000 drought-affected villages have been selected on a priority basis.

- i. Telangana has launched a long-term initiative to ensure water security named ‘Mission Bhagiratha’ (Telangana Water Grid scheme to provide safe drinking water to every household in the rural areas) aimed at the development of a water grid, linking ponds and reservoirs. Another programme, ‘Mission Kakatiya’, aims to restore all the tanks and lakes in the state of Telangana.
- j. Employment generation: The number of days under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) increased in all states that faced drought. Despite some of the above mentioned practical concerns, MGNREGA remains a significant mechanism to deliver drought relief and simultaneously reduce the drought risk through mitigation works.
- k. Karnataka has a real time monitoring system of weather, rain, operated by Karnataka State Natural Disaster Monitoring Center, with 24x7 information support system to serve the farming community, industries and administration with sufficient data to take appropriate decisions.
- l. The Government of India Drought Manual -2009 and the revised manual of 2016, provides various measures for mitigation, preparedness for drought management. It can be adopted by localizing the measures by ensuring more participatory than officious, more demand responsive than supply driven, and in tune with the longer-term development process rather than working in isolation.

6. Recommendations

1. Strengthen and actively promote participatory risk mitigation mechanisms to account for the diversity of needs and environmental conditions in drought mitigation and response. The National Platform for Disaster Risk Reduction (NPDRR) should include drought in its activities.
2. Harness traditional community-based water management practices. Various states in the country, from water-rich north Bihar to water-scarce Rajasthan, have a rich

culture of different community-based management practices that have been internalised as traditional coping mechanisms through the ages. Regular maintenance and participatory development would help in rejuvenating the culture of community-led management of natural resources.

3. Strengthen good practices within the community, while non-performing or risk- and vulnerability-increasing practices and policies should be regulated to avoid mal adaptation. Alignment of policies and programs should be ensured to achieve environmental and social sustainability of all the development actions.
4. Regulation and knowledge management to be included in drought management as part of the functions of the State and District Natural Calamity Committees. Appropriate technology should be promoted, and capacities built at the community level for participatory monitoring of ground water table levels, and use of government own data for practices like water budgeting, water security planning, etc.
5. Strengthen state and district level mechanisms for enforcement of the Ground Water Act, DM Act -2005
6. The opportunities available through Gram Panchayat Development Plans (GPDP) should promote contextualized crop diversification, plan sustainable farm and non-farm activities, identify, notify and protect common property resources, rejuvenate local water harvesting systems, forests, grazing land, etc., foresee construction of water storage and sanitation systems in schools, anganwadis and health facilities.
7. The plans should include water for livestock and small ruminants. Include water for public institutions in drought response planning requirement (tanker supply). Most importantly the plan should cover supply chain system of emergency medicine and immunization.
8. One of the measures to address drought is effective coordination and monitoring, which is an area that needs greater emphasis. This entails involvement of (accredited) NGOs and CBOs in drought mitigation and other responses through their inclusion in mechanisms like District Drought Monitoring Committees and other local platforms for coordination. Align the State Action Plan for Climate

Change (SAPCC) and the State Disaster Management Plans, with role clarity between different departments, especially with Agriculture, Water Resources and Farmers Union. Improve monitoring mechanisms by adopting technology to ensure supply chains are effective, data flow from the ground provides real time data on measures being taken and enable the convergence between various departments, especially those related to children and women.

7. Drought vis-à-vis Children in Karnataka

Karnataka has encountered successive droughts during the last 10 years adversely impacting nutritional status of women & children significantly. According to NFHS 4 (2015-16), in Karnataka about one third (36%) of the children under 5 years are stunted, or too short for their age, which indicates that they have been undernourished for some time.

1. The prevalence of childhood stunting ranged widely in Karnataka from 19 per cent in Mandya district to 56 per cent in Koppal district. Three districts – Gulbarga, Yadgir and Koppal – had a prevalence of over 50 per cent, while the prevalence varied from 40 per cent to 50 per cent in six of the 30 districts of the state. Districts with a high prevalence of stunting are in the northern half of the state.
2. 26% children are wasted, or too thin for their height, which may be due to inadequate food intake or illness in the recent past. About 35% are underweight, which takes into account both chronic and acute under-nutrition. Karnataka is among the states with highest wasting levels across the country and has shown an increase of 48% in the last decade, which is highest in the country. For instance, districts of Gadag in Karnataka has wasting levels as high as 43% followed by Raichur with 34.9% have highest percentage of wasting among children as against national average of 20%.
3. The status of nutrition among women & adolescent girls, in the state is also a matter of concern. Around 20% women aged 15-45 years have BMI (Body Mass Index) below 18.5 kg/m², among these women in the districts like Yadgir (27%), Koppal (26%) & Udupi (27%) show a higher prevalence of undernutrition.

4. Based on the data and co-relating with the continuous drought in the above mentioned districts, it is evident that drought situation is having repercussions on the overall health of children (below 5 years) and women (pregnant and lactating women). Availability of clean drinking water is another issue that is impacting the health of children. The existing deprivations are compounded further during drought.

8. UNICEF Intervention

The drought study 2016 by UNICEF and the findings reiterated its resolve to continue to work on issues related to child nutrition, health, water safety and security, sanitation, education and child protection. It further opened new areas for intervention, especially risk reduction measures and climate change adaption. Increasing events of drought and long dry spell even during monsoon indicates the need to focus on risk reduction and promote climate change adaptation. UNICEF as an organisation works holistically to enable the rights of the children'. In this regard, UNICEF is working closely with Union and State Governments in the areas of effective co-ordination and monitoring of child related programs; improving governance at all levels of administration through technical and technology support. Some of the programs are:

- a. Supporting State Disaster Management Authorities in many States to develop child centric State Disaster Management and District Disaster Management Plans, facilitating the preparation of State Disaster Risk Reduction Roadmap and collaborating in the development of Drought Proofing Plans.
- b. Enabling effective implementation and monitoring of one full meal scheme in the country, with special focus on Telangana, Karnataka and Andhra Pradesh
- c. Providing technical support to Bhagiratha Mission in Telangana
- d. Holistic approach to drought management in Osmanabad (Maharashtra) through District Disaster Management Authority- a pilot project to address risks emerging from drought.

9. Conclusion

1. The Supreme Court of India directions, data from ground, studies/assessments of the impact of drought on individual, families, communities and country indicate how droughts could impact communities and the ecosystem they depend on for survival. Scarcity of water, migration to cities, strikes/bandh conducted by farmers and inter-state tussle over water is all indications of how as a nation we have failed to address drought (stress) effectively. It is well documented that in drought and situation like drought, it is the children and women who are vulnerable due to socio-economic factors.
2. In regions where the economy depends mostly on rain-fed agriculture, a cascading effect of drought is seen through reduced production, reduced availability of feed, fodder and drinking water, worsening human and animal health, their mortality and out-migration, fewer employments, and lower purchasing power, which together lead to poverty and disruption in the national growth rates.
3. There is scientific evidence that low rainfall or any other drivers of drought, need not become a drought situation. But inappropriate water and soil management, poverty and vulnerability, low risk governance capacity and accelerating water demand are drivers of drought risk. Natural factors may lead up to it; but drought is essentially a human-made condition and has to be addressed thus. What is crucial therefore is to be perpetually prepared for drought risk reduction.
4. It is high time that we as a nation introspect our attitudes, approaches, the administrative mechanisms and most importantly our political will to address drought. We need to accept that climate change is real and irreversible, has definite impact on seasons and weather conditions, clearly reflected in the increasing phenomenon of long dry spells and heavy rains at a given point of time. In a fast changing climate scenario, we stakeholders have an added responsibility towards our children and women by minimizing the impact and enabling them to adapt to climate change. Let us ensure that our children continue their schooling, have sufficient nutritious meal, good health and protection from abuse and violence against them.

16. Drought Management Strategies through Integrated Watershed Management

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Drought is a climatic anomaly, characterized by deficient supply of moisture resulting either from sub-normal rainfall, erratic rainfall distribution, higher water need or a combination of all the three factors. Drought is one of the most complicated and least understood natural hazards, affecting more people than any other hazards. National Commission on Agriculture has categorized drought into three types, viz., meteorological drought, hydrological drought and agricultural drought.

In India, most of the drought prone areas fall either in arid or in semi-arid region where the droughts occur more frequently. In Gujarat, East Rajasthan and Western Uttar Pradesh, drought is likely to occur once in three years; in West Rajasthan drought is likely to occur twice in every five years; while in Assam, drought occurrence is very rare and may occur once in fifteen years. Frequency of multi-year (24 months) droughts has shown a statistically significant increase, which is attributed to increase in surface air temperatures and thus drying of the atmosphere. The wavelet analysis of SPEI suggests significant spectral peaks at quasi-biennial (2–3 years), ENSO (5–7 years) and decadal (10–16 years) time scales, with significant multi-decadal variations.

Drought is a creeping phenomenon and its effect can be felt after it has happened. Earlier approach for drought management was to wait until an event occurs and try to mitigate its consequences by whatever means available. Water needs in agricultural sector are high and are going to be very high in future, as several thousand tons of water is required to produce each metric ton of food grains. ICRISAT's Hypothesis of Hope through future climate ready crops and Integrated Watershed Management could be a potential adaptation strategy to cope with the probable increase in drought occurrence due to climate change.

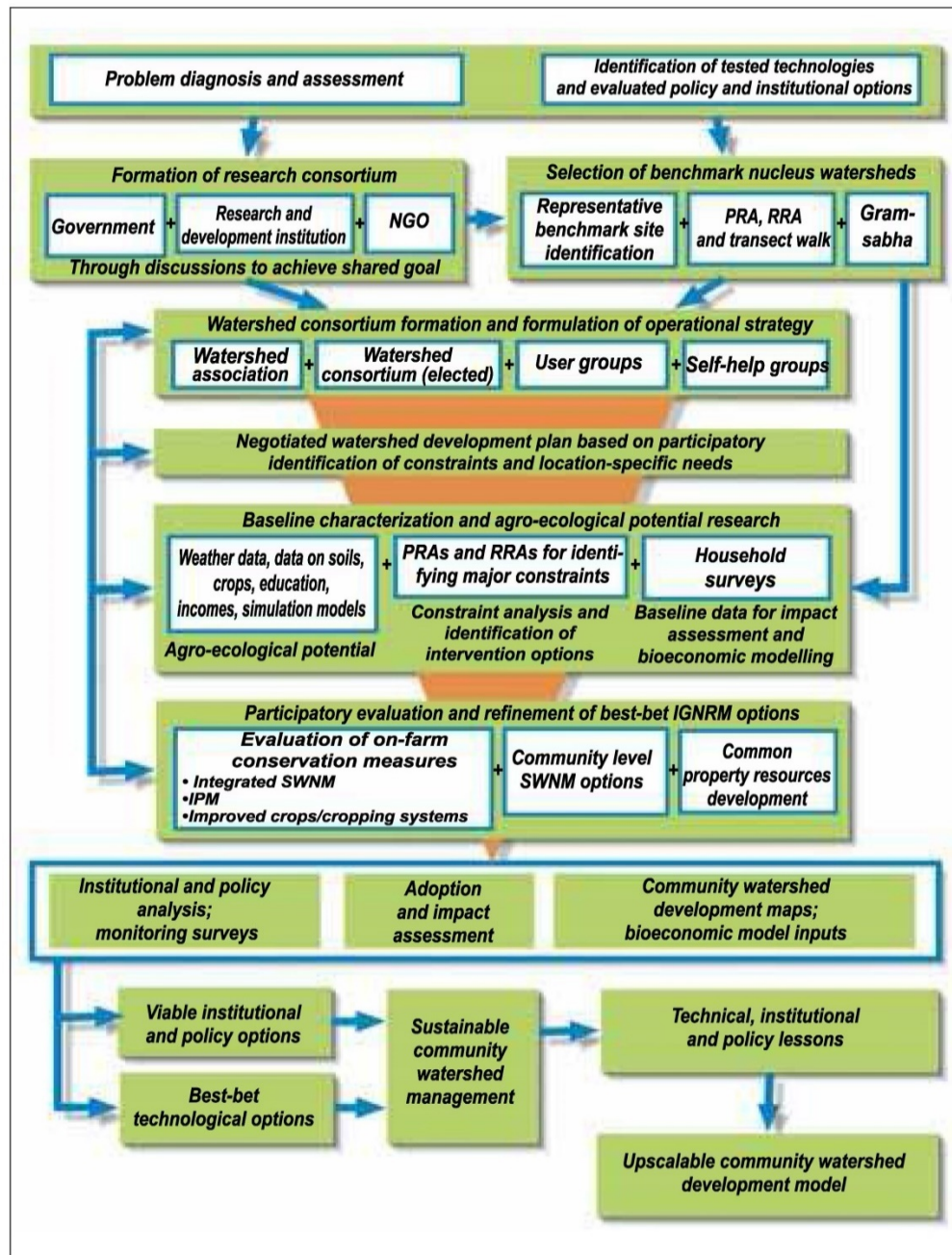
ICRISAT has adopted an integrated genetic and natural resource management (IGNRM) approach to enhance agricultural productivity in rainfed areas, which is a powerful integrative strategy of enhancing agricultural productivity. While addressing the core issue of rural development, this approach maximizes synergies among the disciplines of natural resource management, crop improvement, and social sciences, along with people's empowerment through capacity-building measures. Wani *et al.*, (2009) described the watershed scale as the “entry point” for effective management of smallholder agro-ecosystems for improving livelihoods.

Integrated Watershed Management

The goal of Integrated Watershed Management is to improve livelihood security by minimising the adverse effects of climatic variability while protecting or enhancing the sustainability of the environment and the agricultural resource base through suitable adaptation strategies. ICRISAT in partnership with the NARSs has developed an innovative and up scalable consortium model for managing watersheds holistically for improving livelihoods through an integrated approach. This approach of integrated and participatory watershed development and management has emerged as the cornerstone of rural development in the SAT.

In rural areas, most of the poor make their livelihoods on the use of natural resources, which are degraded and inefficiently used. This is because of the inadequate traditional management practices of managing agriculture as well as the fact that resulting crop yields are much below the expected potential yields.

Integrated watershed management comprises improvement of land and water management, balanced nutrient management, crop diversification, integrated nutrient management including application of micronutrients, improved varieties and integrated pest and disease management is also recommended to bridge the yield gap. Watershed management program is one of the most suitable options for increasing water use efficiency and also as an adaptive strategy to cope with climate change effect in rain fed areas. Increased crop yields by two to four folds in Adarsha watershed demonstrated the impact of integrated approach (Wani *et al.*, 2012).



The four ICEs are:

I	C	Es
Innovate	Convergence	Efficiency
Inclusive	Collective	Equity
Intensive	Consortium	Environment protection
Integrated	Capacity building	Economic gain

This approach has increased crop productivity and cropping intensity, reduced runoff and soil loss as well as increased diversity of crops and livelihood systems.

In-situ conservation of rainwater. The foremost priority for coping with the drought is to enhance the water storage in the soil through in-situ conservation measures by adopting different landforms, enhancing the organic matter content and minimizing the evaporation losses from the soil.

On-farm trials in central India revealed that BBF system resulted in 35% yield advantage over flat system for soybean, and in 21% yield advantage in post-rainy season chickpea. In southern Indian Alfisols, yield advantage of 15 - 20% was observed in maize, soybean and groundnut. It is evident that these yield advantages are due to improved rainfall use efficiency due to improved land management.

Ex-situ conservation: Once the storage capacity of the soil is fully achieved excess water from the fields as well as other areas need to be channeled and harvested by adopting ex-situ conservation measures like gully controlled structures, construction of contour trenches, earthen check dams, masonal check-dams, farm ponds etc.,

Building soil health: Importance of soil organic carbon (SOC) in sustaining productivity is well known. Sequestration of atmospheric carbon dioxide in the soil has the potential to achieve the multiple objectives of improving the soil quality and fertility of the semi-arid tropical soils, increasing crop productivity, addressing climate variability / change, improving livelihoods and maintaining environmental quality. Evidence from a long-term experiment at ICRISAT, Patancheru since 1976 demonstrated the virtuous cycle of persistent yield increase through improved land, water nutrient management on Vertisols in rainfed agriculture.

Increased Productivity through enhanced water use efficiency:

For example in Karnataka, Sujala watershed initiative increased crop productivity up to 30% was recorded by adopting integrated approach of improved cultivars, soil test-based nutrient application and improved management of rainwater in watersheds.

Yield advantages observed with different crop cultivars and improved management in Sujala watersheds of Karnataka, India during 2005-2006 seasons.

Crop	Yield improvement (%)		
	Local Cultivar +IMP ^(a)	HYV+FP ^(b)	HYV ^(c) +IMP
Finger millet	74	22-52	103-123
Groundnut	27	13-36	47-83
Soybean	62	0	83
Sunflower	67	54-150	152-230
Maize	--	26	70
Sorghum	--	--	31

^(a) IMP = Improved Management Practice; ^(b) FP = Farmers' Practice; ^(c) HYV = High-Yielding Variety

Average crop yield and rainwater use efficiency in different management systems during 2010 -13

District	Crops/ Cropping systems	Mean Yield (ton ha ⁻¹)		Increase in rainfall use efficiencies (%)*
		Double cropping with other improved practices	Conventional farmers practice of rainy season fallow	
Raisen	Soybean + Chickpea sequential system	2.23	Nil	42
		1.67	1.73	
Sagar	Soybean + Chickpea sequential system	1.86	Nil	46
		1.62	1.81	

Income-generating Activities: It is important to diversity the sources of income for the farming families which largely helps during the drought period, when the agricultural production is adversely effected, income generating activities like livestock rearing, goat rearing, nursery raising, compost preparation, value addition etc., need to be printed in the watersheds to benefit women and landless people as well as for diversifying the sources of income for the families.

Capacity Building: For up-scaling the benefits of integrated watershed management, there is need to have an articulated strategy based on the main pillar of capacity building of all the stakeholders including farmers–researchers–development workers, policy makers and development investors. New scientific tools, such as remote sensing, geographical information systems (GIS), and crop simulation modeling for the analysis of long-term potential productivity, need to be used as the planning

tools. These tools provide the capabilities for extrapolating and implementing the technologies to other larger watersheds.

This watershed model is more holistic and puts rural communities and their collective actions at centre stage for implementing improved watershed technologies with technical backstopping and convergence by consortium partners.

Greater resilience of crop income in Adarsha Watershed, Kothapally (Ranga Reddy district, Telangana) during the drought year 2002 was indeed due to watershed interventions. While the share of crops in household income declined from 44% to 12% in the non-watershed project villages, crop income remained largely unchanged from 36% to 37% in the watershed village. In the non-watershed villages, large source of income was from non-agricultural activities like migration.

A project “Bhoochetana: Mission to Enhance Productivity of Rainfed Crops in Karnataka” was implemented during 2009 onwards by ICRISAT-led consortium of partners including Government line departments, State Agricultural Universities, community based organizations and others. Under this project, Improved cultivars with improved crop management practices of the crops, increased productivity benefits accrued to be Rs 2596 crores (US\$ 453.34 million) in different districts for different crops during seven years.

Doubling Farmers Income: In response to the Prime Minister of India’s call for Doubling Farmers Income by 2022, ICRISAT led consortium taken up the pilots in eleven districts of Vidarbha region in Maharashtra and seven districts of Bundelkhand region in Uttar Pradesh. This initiative is based on KISAN MITrA (Knowledge-based Integrated Sustainable Agriculture Network- Mission India for Transforming Agriculture) have been initiated. The strategy adopted in KISAN MITrA is holistic-value chain approach through public private consortium for providing science-led demand driven innovations using new science tools such as remote sensing, weather predictions and IT to link the farmers to market. In 18 districts, the strategy for each districts based on the state strategy, growth engines are identified and consortia are formed for Maharashtra and Uttar Pradesh through public private partnership as well as

non-governmental organizations and line departments of state governments of Maharashtra and Uttar Pradesh.



This strategy is based on the agro-ecological potential based farming considering the market demands and its data sets associated with agro-eco-zone planning such as land resources inventory, weather data sets, hydrology, infrastructure availability and markets are collated and use of strategic data analytics using machine learning and artificial intelligence. The crop choices and the crop advisories are to be provided to the farmers. The consortium will enable the Farmer Producer Organizations (FPOs) to add value to their produce and also enable to harness good price through market linkage.

References:

- Wani S.P, Sreedevi T.K, Rockström J and Ramakrishna Y.S. 2009. Rainfed agriculture - Past trend and future prospects. Pages 1-35 *in* Rainfed agriculture: Unlocking the Potential. Comprehensive Assessment of Water Management in Agriculture Series (Wani SP, Rockström J and Oweis T, eds.). CAB International, Wallingford, UK.
- Wani S.P, William D. Dar, Dileep K Guntuku, Kaushal K. Garg and A.V.R. Kesava Rao. 2012. Improved livelihoods and building resilience in the semi-arid tropics: science-led, knowledge-based watershed management, Climate Exchange, The Global Framework for Climate Services, World Meteorological Organization, October 2012, Pages 69-71, ISBN 978-0-9568561-3-5. (<http://www.wmo.int/pages/gfcs/tudor-rose/index.html>).

17. Economic impact of Varuna Mitra on Agriculture: A 24x7 Interactive Help Desk of Karnataka State Natural Disaster Monitoring Centre

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1. Background

In recent times, ICT applications of weather forecasts have been developed to translate meteorological parameters into understandable agricultural terms through advisories. However, the dissemination of weather-based information has been inadequate as compared to the other advisory services for agriculture. The Indian Agri Met i.e. weather forecasting and advisory services is the major source of information to the farmers. To supplement this, a few more services were launched to disseminate weather-related information to the farmers in the form of bulletins and recorded messages without directly interacting with them. Most of these advisories or information dissemination channels were not fully accurate as they dealt with a wide geographical area rather than specific regions as needed by the farmers. However, it is known that there are a large number of unpredictable factors that decide the weather condition. The likelihood of error will be higher in the longer range of forecast. As such, the Indian Meteorological Department (IMD) finds it difficult to forecast local weather conditions with full accuracy. Apart from this, the available weather-based and natural calamities information is not directly disseminated to the farmers.

To fill this gap, VARUNA MITRA services were launched which provides direct information to the farmers and public. This help desk service was started on 1st October 2010 by the “Karnataka State Natural Disaster Monitoring Centre (KSNDMC)” known as the “VARUNA MITRA”, a 24x7 interactive help desk service. It is an Interactive Voice Response (IVR) and is geographic specific to Karnataka. It is superior to other services on two fronts; first, when compared to National Weather forecasts (IMD and

AAS) that has delivered information to farmers by SMS, media and radio, with no direct link to farmers, this service is an interactive service and second, it provides gram panchayat level forecasts on rainfall, relative humidity, wind speed, wind direction and temperature in local languages that can be easily comprehended by farmers. This information assists farmers to take decisions on agricultural activities from sowing to marketing.

The help desk number is 924334533 (mobile) and 080-22745732, 080-22745234 (land lines) with 32 parallel lines that facilitates receiving 32 calls simultaneously at any given point of time. It started with a staff strength of 2 in 2010 (Tele advisors) and has increased to 32 (12 females and 18 males) as number of calls have significantly increased. The weather information, forecast and advisories are also being disseminated through SMS to registered mobile numbers.

The forecasts disseminated to farmers at every 15 minutes are generated based on data and information collected from the Global Positioning Response System (GPRS) enabled and Solar Powered Telemetric Weather Station (TWS) at every 250 sq. km. at 747 hoblis and Telemetric Rain Gauge (TRG) stations covering 25 sq. km. by utilising RKVY funds. In addition, 179 Telemetric Weather Stations were set up in Sujala - III watershed area (11 districts) in 2015-16 (GoK, 2016). The jurisdiction of each telemetric station is 5 sq. km. (Micro-Watershed). These are in addition to 26 Automated Weather Stations (AWS) installed in Karnataka by IMD (IMD Bangalore Centre, 2011), 117 by ISRO (Naveen, 2009) and a few by Agricultural Universities and Water Resources Department. The VARUNA MITRA services covered only a few districts up to 2013 (Shashidhar, 2014). However, post 2013, all the 6073 panchayats and villages with a population of 6175 each were covered in all the districts.

The introduction of this service has replaced indigenous predictions that have frequently been inaccurate and have led to heavy losses to the farmers. This unique programme has garnered immense attention across the Indian States and over 10 States have either established a similar facility or are in the process of setting up an identical system with technical guidance from the KSNDMC.

With this backdrop, the main purpose of the study is to assess the impact of VARUNA MITRA help desk service on cost of cultivation, yield, net income and post-harvest losses and provide suggestions for improving the existing service and expanding the services of Varuna Mitra for enhancing welfare of the farming communities.

The remainder of the paper include three sections. Second section presents data, study area and procedure followed for estimation of impact of Varuna Mitra. Third section focus on results and discussion from macro (secondary data) and micro (primary data from farmers and other stakeholders) analysis. Final section offers conclusions and policy suggestions.

2. Data, Study area and Methodology

2.1. Data and study area

Impact of Varuna Mitra help desk services was assessed using both primary and secondary data. Secondary data was obtained from KSNDMC that consisted of the calls made across districts, purpose of calls, coverage of crops, land holdings, and irrigation status. Data from 2013 to 2017 was considered for analysis.

This information was supplemented by primary data. The impact made by the Varuna Mitra through weather forecast information on the costs, yield and net income, and the perceptions of farmers on the scheme were captured from the primary data. Multistage random sampling technique was employed for the selection of farmers.

In the first stage, the districts were divided into three regions, namely, High Rainfall (>1200mm), Moderate Rainfall (600-1200mm) and Low Rainfall (<600mm) based on the annual rainfall. Further, three districts were selected from each region. The selected districts were, Dakshina Kannada and Udupi, Kodagu, and Shivamogga in the high rainfall region, Chikkamagaluru, Hassan, and Kolar in moderate rainfall region, Tumakuru, Ballari, and Raichur in low rainfall region. As adequate sample size was not available in Dakshina Kannada, neighbouring district of Udupi was included in the sample frame. The selected districts represent 33.33 percent of all districts in the

state and represent 8 of the 10 agro-climatic zones of Karnataka, which indicates the robustness of the sampling procedure to reflect the situation in the entire state. In the second stage, three taluks were selected from each district representing high, medium and low rainfall areas. In the final stage, 50 farmers who obtained information from Varuna Mitra helpdesk service during July 2016 to June 2017 were randomly interviewed using a pre-tested questionnaire. Thus, a total of 1350 sample farmers were interviewed located in 32 taluks of 10 districts.

2.2 Methodology followed for estimating the impact

The impact of Varuna Mitra services on cost of cultivation, yield, net income and post-harvest losses was estimated using following approach. The impact has been estimated considering two situations, namely, with-information and without-information. The difference between the decision taken with-information and without-information expressed in physical and monetary values, which has been considered as an incremental change, which can be positive or negative depending on the impact indicator. Reduction in cost of cultivation, increase in income, increase in yield and decrease in post-harvest losses is considered as gain, whereas increase in cost of cultivation, decrease in income, decrease in yield and increase in post-harvest losses was considered as losses.

Suppose, a farmer wants to apply Plant Protection Chemicals (PPCs) and he wants to know the non-rainy day for application of PPCs, he will call Varuna Mitra help desk for rainfall information. If the farmer has received accurate rainfall information on a particular day as heavy rainfall, then he will post-pone his decision for non-rainy day. By doing so he could save cost, which was supposed to be incurred on PPCs. Otherwise without-information, PPCs applied would have washed away due to heavy rain. The saving in cost is a gain to the farmer.

In the case of sowing stage, rainfall plays a major role. Usually farmers start sowing after a few rainy days. If farmer gets accurate information about the continuous rainfall for few days, he can decide the sowing activity. From this, he could save cost incurred towards supplementary irrigation. This saving in cost is also a gain to the

farmer, which also impose positive outcomes on yield and net income. Sowing at accurate time with timely information will increase the germination percentage, which ultimately reflects in the increase in yield and net income.

In a similar manner, impact has been estimated with-information and without-information for taking decision at various stages of farming viz., ploughing, sowing/germination, vegetative growth, flowering, fruit setting, fertilizer application, PPCs application, irrigation, tank-filling, harvesting, post-harvest management and marketing.

Overall impact has been estimated by aggregating the stage-wise impact to arrive at per acre and per farm impact by using the information provided by Varuna Mitra. Finally, the impacts are presented in terms of two indicators, namely (i) **Net gain or loss** using the results of cost of cultivation, net income and post-harvest losses and (ii) **Yield**.

The impact of Varuna Mitra information specifically on rainfall was presented for major crops viz., paddy, arecanut, coffee, ragi, jowar, mango, redgram/tur, maize, cotton, tomato and chilli. The impact for these crops expressed both in terms of **Net gain or loss** and **Yield**. The reason for considering these crops as it accounts for 61 per cent of the cropping area benefitted by Varuna Mitra Information. The remaining crops are grouped and the impact was estimated only in terms of net gain or loss.

3. Results and Discussion

3.1. Macro Analysis (secondary data)

Secondary data results have shown that the performance of the Programme has been impressive. This is evident from the increase in number of calls since its inception from a meagre 6,565 in 2011 to 10.42 lakh in 2016-2017, which is increasing at a Compound Annual Growth Rate (CAGR) of 61.55 per cent considering all 30 districts in Karnataka. The growth rate across districts ranged between 92.58 per cent in Kodagu district to 13.92 per cent in Dakshina Kannada. Lowest growth rate was observed in Uttara Kannada (37.94%), Dharwad (32.92%), Gadag (29.08%), and Bengaluru urban

(18.83%) whereas highest growth rate was seen in Mysuru (92.25%), Kolar (90.63%), Koppal (89.15%) and Chikkaballapura (83.91%). In terms of the pattern of calls during the drought years, it was found that the number of calls increased with the increase in number of districts that experienced drought. Particularly, the frequency of calls was highest in 2016-17 as the year experienced the lowest rainfall in the last 46 years. If the calls continue to increase at the same growth rate, calls are projected at 63.57 lakhs by 2020. This shows that the programme is advantageous to farmers and other stakeholders, which also substantiates its popularity in the State.

During 2016-17, there were total of 1.76 lakh callers who made 10.42 lakhs calls. It works out to 5,876 beneficiaries per district with an average of 34,724 calls per district and an average of 2,854 calls was made by beneficiaries per day in the State. Among the districts, the highest number of calls was received from Ballari which accounted for 11.08 per cent followed by Tumakuru (8.72%), Raichur (7.24%), Chikkaballapura (7.08%) and Kalaburagi (6.42%).

Among the beneficiaries who called during 2016-17, 99.53 per cent of queries were with regard to rainfall which is very crucial input for agricultural operations and crop survival. The farmer mostly enquired about current day forecasts (63.02%). The kharif season (July-October) received 52.11 per cent of the total calls. Of the various purposes for which the calls were made, majority of the farmers sought information for agriculture (90.39%), followed by horticulture (8.65%), animal husbandry (0.39%) and sericulture (0.57%).

The total of 1.75 lakh farmers owned 56.38 lakh hectares of land, of which irrigated land accounted to 64.54 per cent. This implies that a major proportion of the beneficiaries of Varuna Mitra own irrigated land. The sample farmers sought information on rainfall for 73 crops. Among these crops, 56.95 per cent of the calls pertained to only ten crops. They include- cotton, chilli, onion, ground nut, maize, jowar, ragi, paddy, tur and sugarcane. Among them maize accounted for highest share, both under irrigated and dry land areas with 14.41 per cent of the area, 10.71 per cent of the farmers and 13.80 per cent of the calls. Following, tur accounted for 14.64, 7.99 and 11.05 per cent of area, number of farmers and calls, respectively. Of the calls reported,

a majority of the calls were made during the germination stage of all the crops (37.35%) followed by harvesting (22.40%), sowing (12.45%) and vegetative phase (10.38%). The least number of calls were made at the transplantation stage (0.81%).

3.2. Micro Analysis (Primary data)

Farmers' opinion and perceptions about Varuna Mitra

Over 59 per cent of the farmers learnt about Varuna Mitra from friends followed by RSK (14.8%), and relatives (11.8%). The farmers preferred direct interaction in the local language (Kannada) over the phone as it would facilitate clarifying doubts and provides confidence about the information received during the course of the interaction. At State level, each farmer shared the rainfall information to at least seven farmers, and help desk number to five farmers totalling to 12 farmers. Most of farmers across seasons opined that the quality of calls were good (83.64%) and only a small number of farmers stated that the quality of their calls was poor (1.25%). The reason for the latter was due to poor network and busy lines.

A majority of farmers sought short term rainfall forecast for one to three days and indicated a wide range of accuracy levels of these predictions. Overwhelming proportion of farmers (62.50%) have indicated that the accurate prediction was realised to the extent ranging from 60 to 90 per cent.

Calls made by farmers at different stages of cropping activities

Most of the farmers had called at different stages in the production of the crops (**Fig. 1**). Of the 2601 farmers who called seeking for information, 29 per cent of the farmers had contacted Varuna Mitra during harvesting followed by sowing (19%), PPC application (12.65%). Whereas the least number of farmers had contacted the Help Desk during tank filling (0.04%) and transplanting (0.54%).

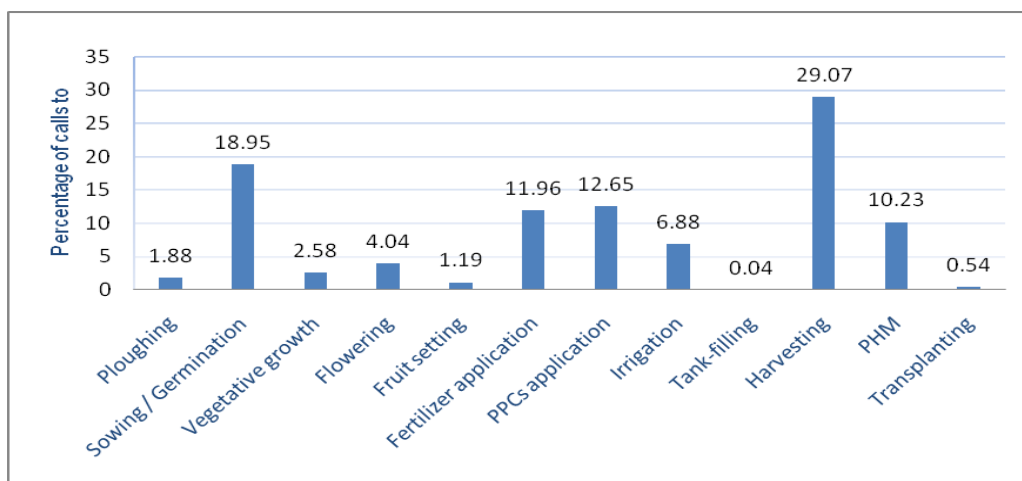


Fig 1: Stage-wise calls made by farmers

Percentage of farmers who perceived a change in Cost, Yield, Income and Post-Harvest losses

A significant per cent of farmers have indicated decrease in cost, increase in income, increase in yield and decrease in post-harvest losses (**Fig.2**). On the whole decrease in cost has been indicated by 666 farmers (49%), increase in yield by 671 farmers (49.70%), increase in net income by 720 farmers (53%) and decrease in post-harvest losses by 535 farmers (40%).

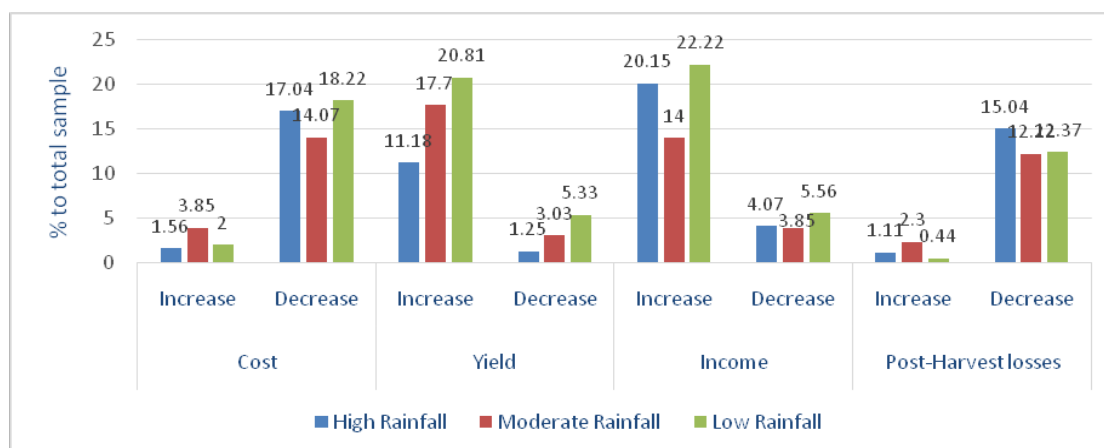


Fig 2: Percentage of farmers who perceived a change in Cost, Yield, Net Income and Post-Harvest losses

Note: High rainfall districts (>1200mm includes DK and Udupi, Kodagu, and Shivamogga); Moderate rainfall districts (1200mm – 600mm includes Chikkamagaluru, Hassan, Kolar); Low rainfall districts (>600mm includes Tumakuru, Ballari, and Raichur).

Percentage incremental change in cost, yield, income, and post-harvest losses

An overall decrease in cost by 6.71 per cent, increase in income by 1.86 per was observed by the farmers. Across regions, the highest decrease in cost was seen in high

rainfall region (7.75%), followed by moderate rainfall region (5.32%). In the case of post-harvest losses, decrease in post-harvest losses by 17.13 per cent was mentioned by 166 farmers in low rainfall region. In the case of moderate and high rainfall regions decrease in post-harvest losses was 4.36 per cent and 2.93 per cent respectively. In the case of percentage change in yield, highest incremental increase was seen in jowar (16.17%) followed by ragi (8.83%), coffee (8.36%) (Fig 3).

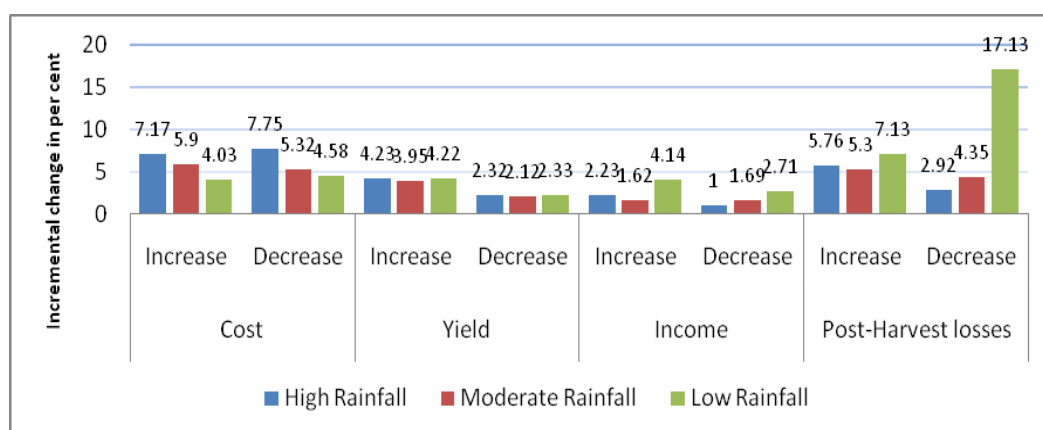


Fig 3: Incremental change in cost, yield, income, and post-harvest losses

Incremental change in cost, Income and Post-Harvest losses

Most of the farmers from all the three rainfall regions indicated a decrease in costs, increase in yield, increase in income and decrease in post-harvest loss. Though the amount of decrease and increase appear to be the same, there is significant difference in the number of farmers who indicated it. Decrease in cost was mentioned by 666 farmers (49%), whereas increase in cost by as less as 100 farmers (7%). Similarly, with regard to income, increase in income was opined by 720 farmers (53%) and decrease in income was indicated by 172 farmers (13%). The highest decrease in cost to an extent of Rs. 6273/ac with the rainfall information was witnessed among 57 coffee farmers (4%) who indicated the decrease at stages of irrigation and fertilizer application. With the forecast of rain for couple of days, the farmers could save the irrigation cost which otherwise would have been incurred. Other crops that followed coffee in terms of decrease in cost were arecanut (Rs.2571/ac), tomato (Rs.2218/ac) and mango (Rs.1268/ac). In terms of income, the highest increase in income was indicated by 42 farmers (3%) in coffee (Rs. 3713/ac), 112 farmers (8%) growing arecanut (Rs.3355/ac),

20 farmers (1%) growing chilli (Rs. 1626/ac) and 16 redgram farmers (1%) (Rs.1559/ac). There were instances of farmers indicating decrease in income as well. Decrease in income was also indicated for the same crops for which increase was mentioned. In the case of coffee, it was Rs. 3521/ac, followed by arecanut (Rs.2658/ac) and chilli (Rs.1627/ac). However, this was mentioned by a fewer farmers. Similarly, in the case of post-harvest losses, increase in the post-harvest loss was Rs.4001 per acre in the moderate rainfall region, whereas the decrease was Rs.3285 per acre. But the decrease was attributed by 168 farmers whereas increase was indicated by 31 farmers (2%) (**Fig 4**).

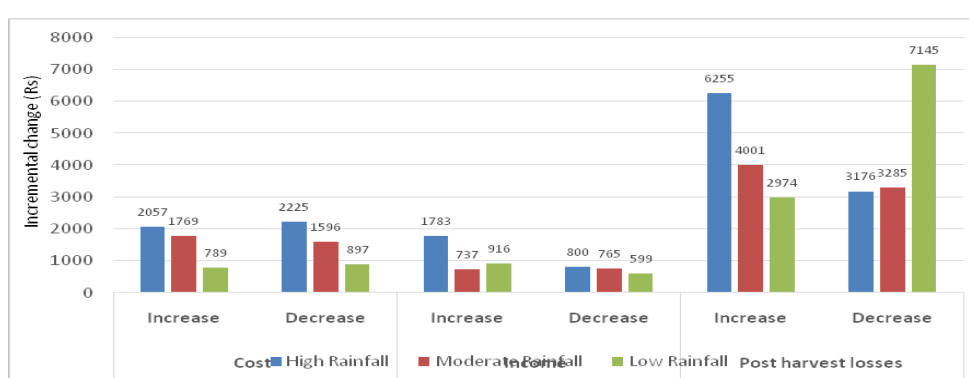


Fig 4: Incremental change in cost of cultivation, income and post-harvest losses

Incremental change in yield across crops

The highest incremental increase in yield was seen in tomato (2.36qtl/ac), followed by jowar (1.67qtl/ac), mango (1.2qtl/ac), maize (0.85qtl/ac) coffee (0.77qtl/ac) and ragi (0.77qtl/ac). The increase in yield was attributed to appropriate time of sowing, fertilizer application and irrigation operations based on the rain forecast received. Decrease in yield was observed to be 3.41 qtl/ac in the case of tomato which exceeds the average incremental increase in yield. However, this was indicated by only 4 farmers, whereas increase in yield was mentioned by 26 farmers (**Fig 5**).

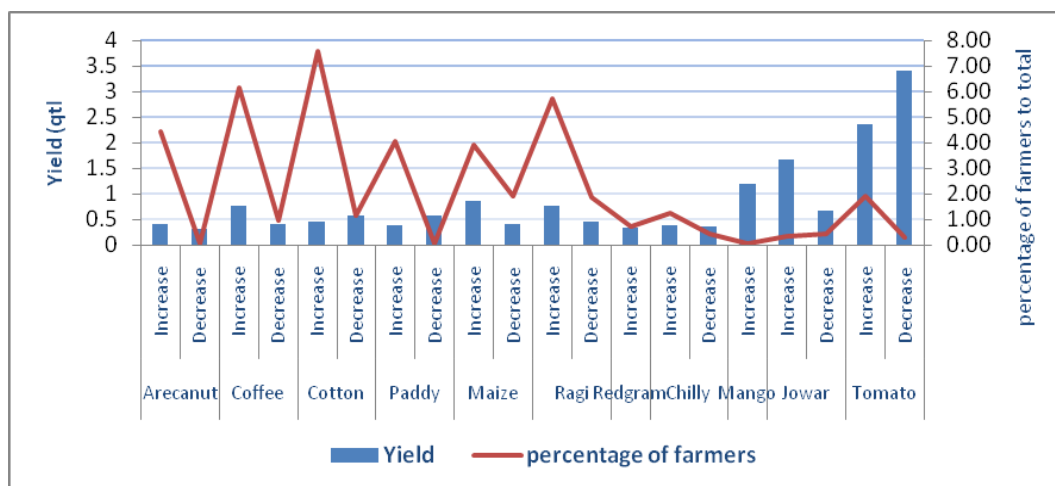


Fig 5: Incremental change in yield across major crops

Incremental change in per acre- net returns and yield and per household net returns

It was seen from the results of incremental net gain across crops (**Fig.6**) that arecanut had realized the highest incremental gain of Rs.12728 per acre followed by coffee (Rs.11118/ac), Chilli (Rs.6818/ac) and tomato (Rs.4338/acre). The highest net gain in the case of arecanut is due to the high market price of the crop, additional yield realised and the post-harvest losses saved with the rainfall forecast information. Similarly saving of costs incurred on irrigation, reduction of post-harvest losses and timely application of fertilizers with the rainfall information in advance has led to increased net gain in coffee. The least incremental net gain was in maize (Rs.1071/ac), and jowar (Rs. 860/ac). With respect to yield, the highest incremental yield realized was in tomato (1.59qtl/ac), jowar (1.28qtl/ac) and mango (1.20qtl/ac) (**Fig 7**).

Highest net return per acre was observed in Raichur (Rs.8903) with cotton, redgram and paddy as prominent crops followed by Kodagu (Rs.6858/ac), and Ballari (Rs.6477/ac) (**Fig 8**). The incremental gain is the result of decrease in cost, increase in income and decrease in post-harvest losses.

The net returns per household was highest in Raichur (Rs.60653) followed by Ballari (Rs.33629), the districts mainly cultivating cotton, paddy and redgram, both districts are in low rainfall region (**Fig 9**). The highest per household net return in Raichur is due to the high operational land holding with 6.81 acres per farmer. This is 92 per cent higher than the average holding of the entire sample farmers (3.53 acres). Among the high rainfall regions, households in Kodagu earned relatively higher net

returns (Rs.29490) and in moderate rainfall regions, Chikkamagaluru (Rs. 15066) realised relatively higher net return (**Fig.9**).

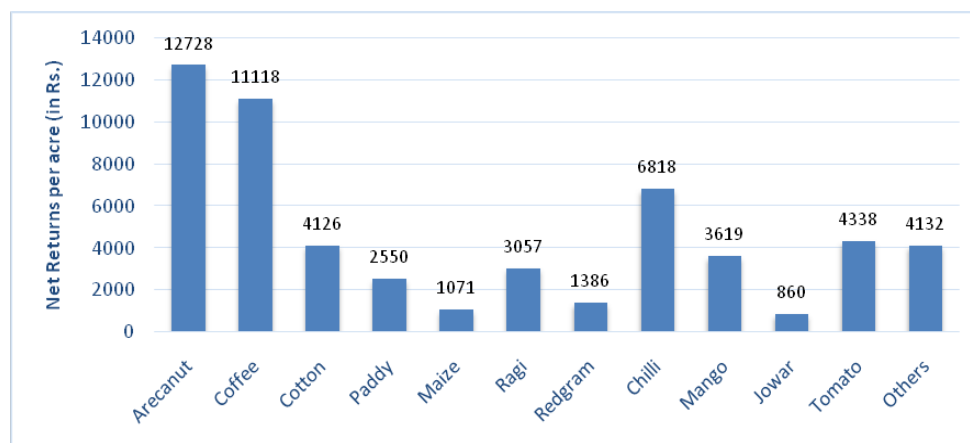


Fig 6: Crop-wise per acre incremental change in net returns per acre

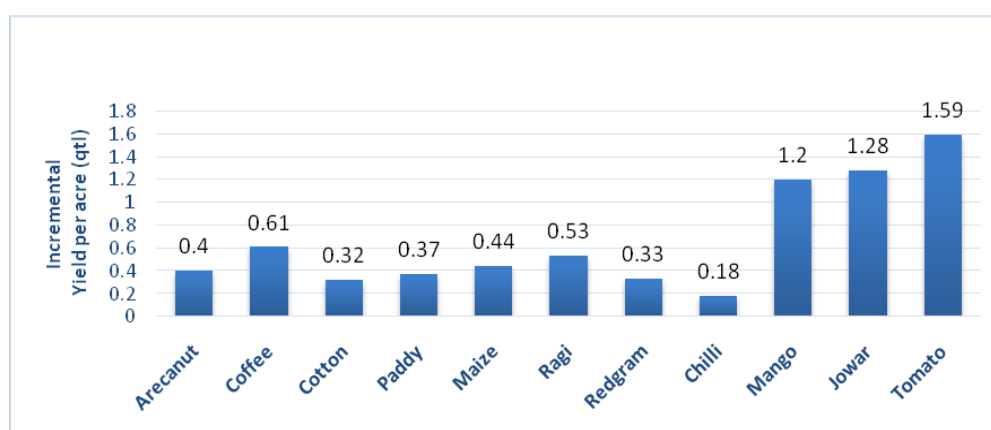


Fig 7: Net yield per acre

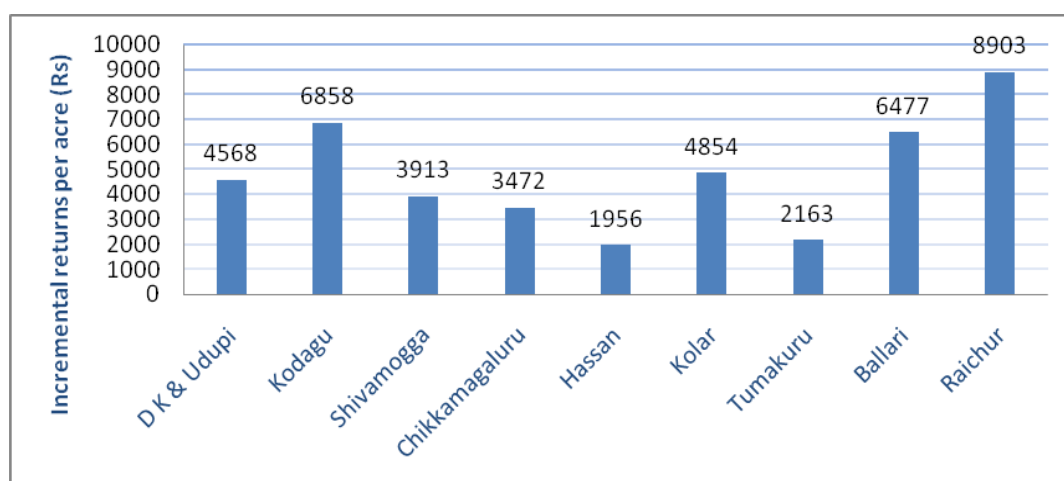


Fig 8: Incremental Return per acre

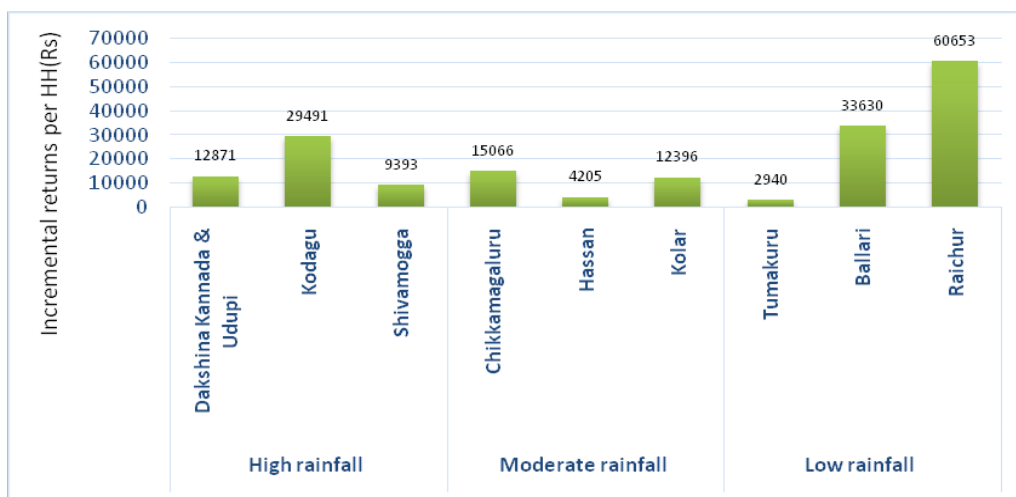


Fig 9: Incremental returns per Household

Opinion of farmers on risk reduction in farming

The weather information obtained from Varuna Mitra has reduced the risk in taking up farming operations by the farmers. Across rainfall regions, 84 per cent of farmers from high rainfall districts, 50 per cent of farmers from moderate rainfall districts and 39 per cent of farmers from low rainfall districts have concurred that information received from Varuna Mitra help-desk reduced their risk.

On the whole, 57 per cent of the farmers were certain about the benefits of risk reduction from weather forecast services, while 18.30 per cent differed in their opinion on risk reduction and 24.37 per cent of the farmers were neutral on the subject (**Fig 10**). All the farmers in Kodagu (100%) opined risk reduction followed by Shivamogga (82%), Chikkamagaluru (78%) and Dakshina Kannada & Udupi (70%).

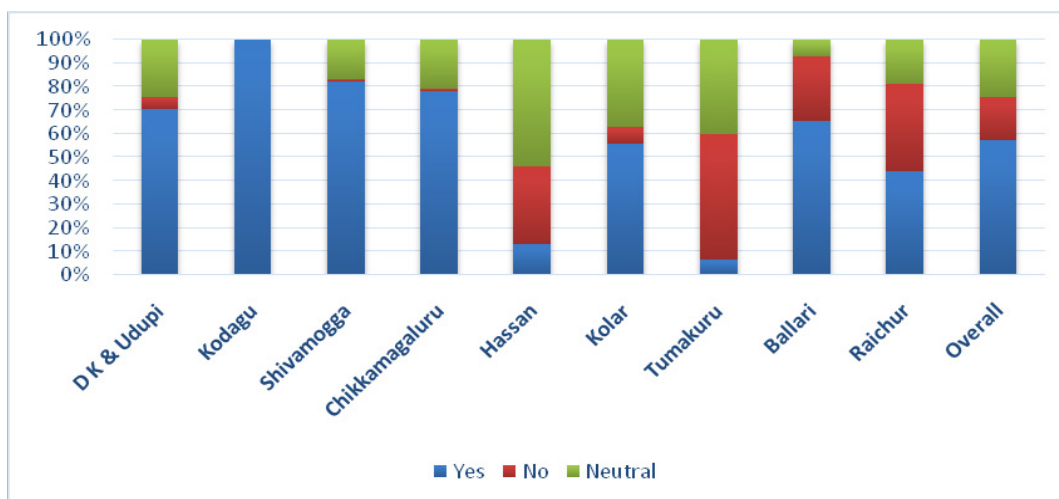


Fig 10: Opinion of farmers on risk reduction in farming

4. Conclusions and Policy Suggestions

4.1. Conclusions

The weather information extended by the Varuna Mitra Help Desk service has contributed in enhancing the welfare of the farmers. A majority of farmers learnt about Varuna Mitra from friends. Across various stages of crop growth, majority of the farmers had called during harvesting stage followed by sowing and germination stage. Scheduling of these operations based on the rainfall forecast was crucial as it impacted their yield and income. A major proportion of farmers (62.50%) have opined that the accurate prediction was realised to the extent ranging from 60 to 90 per cent.

The rainfall information provided by Varuna Mitra has helped the farmers to decrease costs, increase yield, increase income and decrease post-harvest losses as opined by the majority of farmers. Overall decrease in cost by 6.71 per cent, increase in income by 1.86 per was observed by the farmers. On the whole decrease in cost was indicated to an extent of Rs.1695 per acre by 666 farmers (49%), increase in yield by 671 farmers (36%), increase in income to an extent of Rs.826 per acre by 720 farmers (53%) and decrease in post-harvest loss by 535 farmers (40%).

The highest incremental net gain was realized in arecanut growing farmers (Rs.12727/ac) followed by Coffee (Rs.11118/ac), whereas highest incremental yield was seen in tomato (1.59qtl), jowar (1.28qtl) and mango (1.2qtl). Across districts, highest incremental net gain was seen in Raichur (Rs.8903/ac), followed by Kodagu (Rs.6858/ac) and Ballari (Rs.6477/ac). Relatively higher per household incremental income was noticed in low rainfall districts namely Raichur (Rs.60653) and Ballari (Rs.33629).

It is interesting to note that in the wake of climate change and vagaries of monsoon, 84 per cent of farmers from high rainfall districts, 50 per cent of farmers from moderate rainfall districts and 39 per cent of farmers from low rainfall districts have indicated that information received from Varuna Mitra help-desk on rainfall forecast reduced their risk due to its accuracy.

4.2. Policy Suggestions

Results has revealed that Varuna Mitra has performed notably well in addressing farmers' queries on weather forecasts and is a successful initiative to be showcased as a Best Practice in weather management especially during droughts. However, impact evaluation has provided insights for improving the existing services as well as its expansion aiming towards larger gains to the farming community.

- Nearly 1.76 lakh beneficiaries sought information from Varuna Mitra during the period, July 2016-June 2017, which accounted for 2.67 per cent of the cultivators in Karnataka as per 2011 Census. Therefore, there is a need to increase accessibility and awareness among more farmers. In this direction, efforts of Agriculture and Horticulture Department are crucial. They should alert and give responsibility to the PDOs of the Gram panchayats or the RSKs to disseminate the weather forecast received from Varuna Mitra in addition to dissemination of Varuna Mitra helpline number.
- KSNDMC, IMD, ISRO, Agriculture Universities and Water Resources Department has installed telemetric weather stations at various locations in the State. In order to further increase the accuracy level, special efforts are needed by KSNDMC to utilize the information from all these sources.
- Call dropping followed by the irregularity in sending SMSs were observed. The other problems were busy line and poor voice clarity. This could be addressed by increasing the telephone lines and employing staff as number of calls is increasing at a CAGR of 62 per cent between 2013 to 2017.
- Most of the farmers have opined that they require also agro-advisories from sowing to marketing stage. Hence Agriculture and Horticulture Universities should identify a nodal help desk (KVKs) in each district for providing Agri-advisories to farmers. In this regard, KSNDMC can forward such calls to these nodal centres for attending to the farmers queries immediately. Further, Department of Marketing and Inspection's Agmark net may be interfaced with Varuna Mitra for providing market information. Through such integration, farmers can be richly benefitted.

References

Database, <https://www.ksndmc.org>

1. GoK (2016). Karnataka Watershed Development Project-II (Sujala-III), watershed.kar.nic.in/Introd.pd
2. Naveen Y (2009). ISRO Weather Station Will Study Tumakuru Climate, *The Times of India*, September 18.
3. Shashidar Hegde (2014). Varuna Mitranige Rytharinda Karagala Male, *Vijaya Karnataka (Kannada)*, July 3.

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18. Drought Management Strategies- Best Practices

Directorate of Research

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1. Background:

Karnataka is the upper riparian states in Southern India covering an area of 1.92 lakh sq.km with varied topography. Though, it has a cultivable area of 1.05 lakh sq.ks, only 35 per cent of it is under irrigation. Arid regions which receive less than 750 mm of rainfall are prone to drought and constitute more than 2 / 3rd of the geographical area in the State. The study of the Directorate and Statistics (1984) on the rainfall-data over 80 years indicated about 20 drought-years and the highest number of drought years were experienced by Mandya, Kolar, Tumkur, Chitradurga and Mysore districts. As a result, droughts have become annual features in several parts of the State. Recently, the state is growing increasingly vulnerable to drought conditions every year. Analysis of past 13 year rainfall (between 2004 and 2016), the state have enjoyed normal rainfall over all taluks for only two years. Of the 176 taluks in the state, 109 taluks have faced drought for at least four years between 2011 and 2015.

Drought assessment study by KSNDMC indicates that the situation might get worse in the next few years. According to the data of drought-hit taluks over the past 12 years, only coastal districts which generally record heavy rainfall are exempt from drought. However, these areas too are increasingly becoming vulnerable with erratic rainfall distribution. KSNDMC has calculated the drought probability for different taluks and indicated highest probability for drought (86 per cent) in Chikkaballapur, Aland, Jewargi and Shirahatti taluk. Also, 135 of the 176 taluks have a drought probability of over 50 per cent. A large number of them have suffered droughts for at least eight years of the past 12 years.

Erratic weather is the main reason for drought in the state. The amount of rainfall has not altered widely in the state over past century, but the distribution of rainfall, both

temporal and spatial, has been very erratic and such conditions are detrimental to agriculture. Though new techniques are being developed to ensure that crops do not fail, such techniques are yet to implement fully for increasing water conservation measures to assist farmers and to wade through the climate crisis.

AICRP on Dryland Agriculture, UAS, Bengaluru has developed several drought proofing mechanisms and verified their performance through Operation Research Project (ORP) and National Innovations on Climate Resilient Agriculture (NICRA) Projects. The experience of the technological implementation on drought escape and drought proofing mechanisms are summarised below.

2. Drought management Strategies adopted:

During aberrant weather conditions, the following contingency measures were adopted for sustainability during different drought scenarios.

a) Delayed onset of monsoon:

- ✓ Transplanting of seedlings (finger millet, pigeonpea and chilli) raised in staggered nursery after the receipt of rainfall
- ✓ Use short duration varieties and crop according to sowing window
- ✓ Dry sowing: when the soil is completely dry and anticipation of rains within 8-10 days, dry sowing using 50% higher seed rate (20 kg/ha) in finger millet

b) Early season drought:

- ✓ Change of crop according to sowing window
- ✓ Use short duration varieties matching the showing windows
- ✓ Thinning / gap filling
- ✓ Re-sowing with contingent crop / variety
- ✓ Seed hardening

c) Mid season drought:

- ✓ Repeated inter-cultivation to remove weeds and create dust mulch
- ✓ Remove weak seedlings and weeds to reduce plant population and use them as mulch
- ✓ Protective irrigation from the harvested farm pond water at critical crop stages

- ✓ Potassium spray

d) Early withdrawal of monsoon / end season drought:

- ✓ Protective irrigation from the harvested water in the farm pond at critical stages of crop growth
- ✓ Mulching with organic residues, including removed weeds from the fields
- ✓ Harvest for fodder in cereals (finger millet, maize etc) and vegetable in pulses / vegetables

3. Implementation of Technology

- ❖ **Transplanting of seedlings (finger millet, pigeonpea and chilli) raised in staggered nursery after the receipt of rainfall:** Finger millet is able to withstand transplanting shock, provides an opportunity to establish seedlings in the nursery. Nursery beds were prepared in 1/10th of total sowing area by sowing finger millet seeds on seedbeds with the available farm pond water. Also, pigeonpea seedlings were established in polybags and transplanted in the main field at 30-45 days age
- ❖ **Use short duration varieties and change of crop according to sowing window:** The sowing windows under dry lands are largely dependent on onset of monsoon. Selection of right variety for right sowing time reduces half of the risk under dryland situation. Long duration varieties for early sowing and short duration varieties for late sowing were implemented. Also, when the sowing window is exhausted for a particular crop, short duration contingent crops like field bean, cowpea, horse gram etc were implemented.
- ❖ **Dry sowing:** When rainfall was delayed and expected within 8-10 days, finger millet was sown in large areas with 50% higher seed rate (19 kg/ha).
- ❖ **Thinning / gap filling:** Completed sowing sequenced with early season drought was addressed through gap filling the seeds or transplanting the seedling from the excessively germinated places to the gap where sprouting was not observed.

- ❖ **Re-sowing** with contingent crop / variety: When the germinated population is below 30%, re-sowing after retrieving from the drought was attended for early season drought.
- ❖ **Seed hardening:** Seeds were soaked in water and shade dried to induce drought tolerance.
- ❖ **Repeated inter-cultivation:** was enforced to break capillary column and create dust mulch to avoid evaporative moisture loss was implemented through custom hiring centre during mid season drought.
- ❖ **Potassium spray:** Advised to spray potassium @ 1% during early dry spell in case of mid season drought to regulate stomatal movements in plant to reduce transpiration.
- ❖ **Thinning plant population, weeding and mulching:** In mid and end season drought situation, plant population were reduced through thinning weak seedlings and weeds were removed, and use as mulch to avoid inter & intra plant competition and reduce evaporation losses.
- ❖ **Protective irrigation:** Harvested water in the farm pond were used for protective irrigation through sprinkler during the critical stages of crop in case of mid and end season drought.
- ❖ **Harvesting for vegetable or fodder:** In case of end drought, crop was harvested for fodder in cereals viz., finger millet, maize etc and vegetables in pulses / vegetable crops viz., pigeonpea, cowpea, field bean etc

4. Impact of implemented technologies in minimising losses and improve coping capacity of the community.

The economic impact studies indicated that there was considerable benefit to farmers who adopted the drought management practices. The per cent gain in income due to adoption of suggested contingency cropping systems ranged from 22 to 379 over traditional cropping systems. The yield increase in cropping systems viz., finger millet + pigeonpea, groundnut + pigeonpea, pigeonpea + cowpea and pigeonpea + field bean

was to the tune of 1040, 741, 481 and 594 kg ha⁻¹, respectively. Transplanting of finger millet registered higher yield compared to direct sown situations. In the eastern dry zone of Karnataka, the farmers who have adopted the drought management strategies have realized an average additional benefit of 31.4, 24.7, and 16.2% in finger millet, pigeonpea, field bean, respectively. Majority of farmers who followed the drought management strategies were able to reduce the crop losses.

Due to the regular onset of monsoon during 2011, 2013 and 2014, long duration variety MR-1 sown during the month of July recorded higher grain yield, net returns and B: C ratio compared to medium duration variety. Delayed onset of monsoon during 2012, farmers selected medium duration variety (GPU-28) for late sowing in the month of August. The farmers who selected and sown GPU-28 have realized higher grain yield, net returns and B: C ratio (1720 kg/ha, Rs. 18096/ha and 2.31, respectively), while the other farmers who selected long duration variety (MR-1) even under the late onset of monsoon and incurred huge losses.

Real time weather forecast is a useful tool for enhancing the production and income. Farmers received weather forecast based agro-advisories, including selection of suitable crops and varieties on real time basis recorded 20-30 per cent increased yield and reduced cost of cultivation led to increased profit.

5. Shortcomings in implementation of available technologies.

Finger millet varieties- The sowing window for different finger millet varieties was there only up to August. Availability of seeds at the sowing time is a major shortcoming.

***In situ* moisture conservation practices through conservation furrow in finger millet and groundnut based cropping system:** Conservation furrow improves infiltration opportunity time for rain water and sustain the crop during drought period for only 20 to 25 days. Prolonged dry spell over 25 days harm the crop with all management.

Potassium spray during mid season drought: Application of 1% KCl (MOP) during drought when the plant starts expressing wilting symptom. Plant tolerance to drought only up to 15-20 days under potassium spray. Delayed potassium spray doesn't have any advantage.

6. Recommendation for improvement/ correction of the available technologies

- ❖ Soils with high organic matter (OM) and aggregates can absorb and hold water during rainfall events and deliver it to plants during dry spells. Hence, soil health management through organics needs prioritization.
- ❖ Alternative organic sources: Growing legumes viz., horse gram, cowpea, field bean etc during early *kharif* and *in-situ* incorporation into the soil as green manure, tank silt application, ex-situ green manures viz., glyricidia can provide organic manure alternatively.
- ❖ Integrated nutrient management through application of organics, biofertilizers and manufactured fertilizers in recommended quantity is advantageous
- ❖ Timely operations specially sowing, inter-cultivation needs encouragement through custom hiring centres
- ❖ Integrated farming system approach needs emphasis
- ❖ Alternate land use systems viz., agri-horti system should be encouraged as a drought mitigation and drought proofing mechanism.

7. Best drought management practices

1. Contour cultivation
2. *In-situ* moisture conservation through moisture conservation furrow in finger millet and groundnut based cropping system
3. Transplanting in finger millet under delayed sowing
4. Maintenance of optimum plant population
5. Balanced nutrition through INM / soil test based approach

6. Drought tolerant crop / variety
7. Inter-cropping systems
8. Good weed management practices
9. Repeated inter-cultivation
10. Protective irrigation from harvested farm pond water during critical stages
11. Implementation of Agro-advisories advisory services

19. Role of Agromet Advisories in the Drought Management in Karnataka

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Agromet Advisory plays a very important role in day to day activities of farming based on the prevailing and forecasted weather of a region. Agromet advisories also include recommendations for the mitigation strategies for adoption by the farming community whenever the crops experience the drought or inadequate soil moisture situation in different crop growth stages. As a part of the program under the Agromet project in UAS Bangalore, Agromet advisories have been issued twice a week during the crop growing period to the 60 selected farmers from Chintamani taluk, Chikkaballapur district and Magadi Taluk of Ramanagara district. Further, success of each advisory disseminated to the farmers is assessed by regular estimation of savings on each item of the advisory realized at the farmers level and economic benefit/loss on adoption of the agro advisory issued by the Agro met division is compared with the non-AAS farmers by calculating benefit-cost ratio.

Among 616 AAS issued, 379 AAS recorded direct economic benefit by saving Rs. 37 lakhs. B:C ratio calculated for 5 years recorded were 2.62, 2.61, 2.59, 2.22 for vegetables, fruits, flowers and field crops respectively. Timely advisories helped the grapes farmers of Patrenahalli and Nayanahalli village, Chikkaballapur district to decide timely irrigation, pruning, weeding, spraying and harvesting etc. These timely practices reduced the labour wages, pesticides costs and also lead to achieve better yield with overall benefits from grape growers alone was Rs.2.41Crores. Double cropping of field bean- horsegram gave benefit of 17.25 lakhs in project area of Kuthanagere micro-watershed even during drought year (2016) with deficit rainfall (-26.2%).

Impact of AAS issued:

An average of around 62 per cent of the advisories issued from 2011 was effectively used by the farmers. Among the 616 AAS issued, 379 AAS had recorded direct economic benefit by saving Rs. 37 lakhs to the 550 farmers from 2011 to 2016 (NICRA, 2011 to 2016). Thus, on an average Rs.6808 was saved by each farmer (Table 1)

Benefit : Cost Ratio of AAS and non-AAS farmers: Table-2 indicates that among the different crops of adapted villages, vegetable crops recorded higher B:C ratio (2.62) followed by fruit crops (2.61), flower crops (2.59) and field crops (2.2) against ‘Non-AAS farmers’ i.e. fruit crops (1.72), vegetable crops (1.61), field crops (1.57) and flower crops (1.42) respectively.

SUCCESS STORY OF CLIMATE RESILIENT PRACTICES:

Case study-1: Productivity enhancement in grapes due to agromet advisories in Chikkaballapur

Water table of Chikkaballapur – Kolar belt of grapes is highly affected beyond rejuvenation. To address this problem, Agromet advisories (AAS) based on weather forecast issued twice a week to the farmers of Patrenahalli and Nayanahalli villages of Chikkaballapur taluk. Partial budgeting of grapes cultivation through AAS has been done for two years (NICRA, 2015 and 2016).

Area covered: Nearly 200 farmers were monitored under the project out of which 150 were grape growers in an area of 90 hectares.

More crop per drop: All the grape growers were advised for drip irrigation through synergy from state horticultural department, watershed department and KVK etc. The farmers were given subsidy for drip irrigation through these line departments and advisories were given from NICRA (National Innovations Climate Resilient Agriculture) project with respect to schedule of irrigation based on rainfall forecast. This resulted in the best water use efficiency besides the quality of produce. Among the

advisories given, timely pruning was the best advice given based on the rainfall forecast and most of the AAS farmers followed this advice, thus resulted in higher yield, quality bunches and premier market rates due to appealing color and less disease infestation.

No pests, diseases and birds attack: Weather forecast helped in forecasting pests and diseases. Low relative humidity ($RH < 80$) is highly favorable to powdery mildew disease and high RH (> 90) and intermittent rains with less temperature ($17-25^{\circ}\text{C}$) is favorable to downy mildew. These two diseases are problematic and cause significant yield loss in grapes. These two diseases are effectively managed through advisories. Grape farmers were also advised to use the nylon mesh around the grape plantation to restrict the entry of birds so that damage and yield loss could be minimized effectively.

Higher income: Timely advisories helped the farmers to decide timely cultivation practices viz., irrigation, pruning, weeding, spraying and harvesting etc. These timely practices reduced the labour wages, pesticides costs and also lead to achieve better yield by the farmers.

Partial budgeting (Table-3) to assess the impact of agromet advisories in grapes revealed the following points:

Additional returns due to agromet advisories from sample survey of AAS farmers was **Rs.2,48,000 per ha.**

Reduced cost due to savings in irrigation, pesticides spray and timely pruning was to the extent of **Rs.20,000 per ha**

The total net gain including the total additional return and reduced cost was **Rs.2,68,000 per ha**

Overall benefits from the project due to Agromet advisories from grape growers alone was **Rs.2.41Crores**, including the synergy from line departments, KVKs, Agricultural Research Stations and NGOs in the district

Case study-2: Field bean- Horse gram Double Cropping System:

Ramanagara is one of the south interior districts of Karnataka famous for finger millet, field bean, Redgram, ground nut and mango. Besides these, mulberry cultivation for silk rearing was an age old livelihood enterprise dwindling in the recent years. Due to the intervention by the University of Agricultural Sciences, Bangalore under watershed development programme, mango based Agri-horti system was recommended and now has become a very popular practice throughout the district. Therefore, instead of only finger millet mono cropping, field bean- finger millet double cropping or field bean-horse gram double cropping systems were advised to the farmers under NICRA project in operation at Kuthanagere micro watershed (NICRA, 2016). Farmers' were informed of the weather condition prevailing in the next five days besides long range weather forecast and extreme weather events during the cropping season through block level agromet advisories twice a week.

Area covered: Nearly 100 farmers were monitored under the project out of which 40 had adopted the double cropping systems based on our advice instead of mono cropping of finger millet only. The total area covered under double cropping systems of field bean-horse gram was around 50 hectares in the project area of Kuthanagere micro watershed.

Bumper crop of field bean as a vegetable: Based on the advice under NICRA project, farmers who have sown field bean in May making the best use of pre monsoon showers got good yield of the crop to the extent of 20 quintals of vegetable pod per hectare. At the market rate of Rs. 40 per kg. The profit realized from field bean alone was Rs.80,000 per hectare.

Second crop after field bean: Finger millet is the staple food crop of the farmers' and invariably the farmers transplant the crop immediately after the harvest of field bean in the month of August. Unfortunately this year, there were no soaking rains of more than 20 mm to undertake the transplant of finger millet in the month of August. Therefore the farmers were advised horse gram+ niger intercropping after field bean instead of finger millet as a second crop. The farmers of Ramanagara consider horse gram as poor man's meat and niger as poor man's ghee. Therefore they readily

accepted to take up the second crop of horse gram intercropped with Niger in August. These two crops yielded better than finger millet since failure of rains coincided with tillering and flowering stages of finger millets. The dry spell continued in September (-77.3 %), October (-52.4%) and November (-92.9%) also. Thus, income from niger + horse gram intercropping was nearly Rs.20,000 per ha as against Rs.3,500 per ha from finger millet.

Higher Income from field bean- horse gram + niger: Timely advisories helped the farmers for the successful double cropping system of field bean followed by horse gram intercropped with niger.

Partial budgeting (Table-4 & 5) to assess the benefits of climate resilient practice revealed the following points.

The income enhancement through this climate resilient practice was Rs.1,00,500 as compared to Rs.35,500 per ha with single cropping of finger millet. The net gain from the double cropping of field bean followed by horse gram plus niger was Rs.34,500 per ha.

The Overall benefit from the project was $\text{Rs.34,000} \times 50 \text{ ha} = 17.25 \text{ lakhs}$ in the project area of Kuthanagere micro watershed even during the drought year of 2016 with deficit rainfall (-26.2 %).

The expected horizontal spread of this climate resilient system is over 200 ha during 2017-18. The additional employment created due to the climate resilient system was 75 man days per ha. Cumulative overall benefit for the project period was expected upto one crore in the next year.

Case study-3: Impact of agromet advisory in coffee plantation in Malnad region (Hilly zone)

Karnataka is India's largest coffee producing state, contributing to nearly 70 per cent of the total production. The most commonly used coffee beans

are Arabica and Robusta grown in the hills of Karnataka (Kodagu, Chikkamagaluru and Hassan), Kerala (Malabar region) and Tamil Nadu (Nilgiris District, Yercaud and Kodaikanal). Coffees gain aromatics in high altitudes between 1000-1500 mts above MSL, besides sparse shading through inter planting with spices such as cardamom, cinnamon, clove and nutmeg, storage and handling functions. Growing altitudes range between 1000 m (3300 ft) to 1500 m (4900 ft) above sea level for *Arabica* (premier coffee) and 500 m (1600 ft) to 1000 m (3300 ft) for *Robusta* (though of lower quality, it is robust to environment conditions). Ideally, both *Arabica* and *Robusta* are planted in well drained soil conditions that favor rich organic matter that is slightly acidic (pH 6.0–6.5). However, India's coffees tend to be moderately acidic which can lead to either a balanced and sweet taste, or a listless and inert one. Slopes of *Arabica* tend to be gentle to moderate, while *Robusta* slopes are gentle to fairly level.

Climatic conditions

Ideal climatic conditions to grow coffee are related to temperature and rainfall; temperatures in the range of 23 °C to 28 °C with rainfall incidence in the range of 1500–2000 mm, followed by a dry spell of 2–3 months suit the Arabica variety. Cold temperatures closer to freezing conditions are not suitable to grow coffee. Where the region rainfall is less than 1000 mm, providing irrigation facilities is essential. In the tropical of the south Indian hills, these conditions prevail leading to coffee plantations flourishing in large numbers. Relative humidity for Arabica ranges 70–80% while for Robusta it ranges 80–90%. Stress during December to January extending up to February is important for flowering.

- The flower buds (spikes) burst out on each and every branch nodes due to the moisture stress and cold climate during December to February.
- After the flower bud initiation, coffee plant needs rain for full blooming. It is called as blossom showers. If the rain does not occur, farmers resort to artificial raining through rain gun/ sprinklers.

- When coffee plantations are in full bloom it is a delightful sight to watch with scenic landscape and appealing aroma. However, well distributed pre monsoon showers during March to May, play very important role for full blooming and maturity of the fruits
- Blooming of the spikes takes place immediately during night hours followed by pollination and fertilization. Insects and bees contribute to 33% (fig-2) of the pollination where as remaining 67% is through wind. For full blooming 4-5 days is needed. Rainfall during this period, play very important role for full blooming. Therefore, Agromet advisory during this period, based on rainfall and relative humidity forecast play a crucial role on the yield and income of the farmers. In the event of no rainfall forecasted during February and March, planters will resort to artificial raining through sprinklers. Seepage ponds (3.a) in the valleys serve the water needs of coffee plantation on the adjoining hill slopes. There is lot of demand for digging seepage ponds by the planters through the watershed and NAREGA schemes.
- Some of the planters, have dug the seepage ponds (fig-3) based on our advice and used the same for artificial raining as and when required. Figure 3 depicts blossoming of coffee through artificial blossom showers.
- For this purpose, planters take every step to conserve the soil moisture on plantation hill slopes through contour, trenching and mulching and prepare for artificial raining in the event of no natural rain.
- Abnormal rainfall impacts on coffee noticed are presented in figure-4. Most observed impacts are:
 - (a) Unseasonal flowering due to unseasonal rains
 - (b) Damage to coffee cherries caused by drought in the final stage of ripening
 - (c) Bean damage as a result of low rainfall between weeks 14 and 20 of fruit development
- Finally, agromet advisories based on weather forecasts and land resources advisories for soil moisture conservation (trenching and mulching across the slope

between coffee rows) goes a long way in proper flowering, fruiting, disease control, yield and income of the farmers in 2017

Case study-4: Millet based farming: Coping with weather extremities in 2017, Southern Karnataka

2017 was characterized by normal onset with early season drought. June and July experienced deficit rainfall in Kuthanagere NICRA village to the extent of -9 % and -68 %. Hence, weather based contingent crop plan was suggested for early season drought. Short duration finger millet variety (GPU-28, fig-1) was suggested for August 1st week sowing. Rainfall from August onwards was surplus to the extent of 55.4 % in August, 49.1 % in September and 62.4 % in October. Early exit of rain with deficit rainfall in November and December resulted in poor seed filling in long duration varieties. However, GPU-28 (Table-6) early maturing in 110 days was a tailor made variety for 2017 rainfall distribution pattern. Our timely advise of short duration variety in NICRA villages could reduce climate change vulnerability besides addressing the problems of malnutrition in the villages. The heavy down pour in August, September and October would have eroded the soil without our timely advise of across the slope cultivation, strengthening of bunds, repeated Intercultivation, surplus rainwater harvesting in farm ponds, nala bund and check dams.

Case study-5: Revival of Millet based systems

Small millets particularly finger millet is a staple food crop of southern Karnataka. However, use of traditional varieties and poor knowledge of high yielding and short duration varieties resulted in low yields with heavy weed infestation due to excess rain in August. With a broad objective of reducing the climate change vulnerability and for promoting balanced nutritive millet based inter cropping and double cropping systems were also suggested to the farmers of NICRA village. If one crop fails due to poor coincidence of favorable rainfall with critical stages of the crop, another crop may give good yield is the principle of intercropping /double cropping. There were nearly 30 farmers (Table-7) who followed our timely advice of short duration variety besides soil

conservation measures and rain water harvesting which brought added income (Rs. 15 to 30 thousand).

Case study-6: Tamarind- A Resistant crop to hail storm in Tumkur district

Duragadanagenahalli is a NICRA village under technology demonstration centre (TDC) of KVK Hirehalli in Korategere taluk of Tumkur district. The village receives around 746 mm of rainfall in 46 rainy days. Besides low rainfall, the soil of the NICRA village is gravelly sandy loam with low moisture holding capacity on undulated terrain. Among the dry land orchard crops, tamarind is suitable in terms of soil- site and climatic suitability criteria. In addition to this, tamarind is less susceptible to hail storm as compared to mango, another prominent dry land orchard crop of area. Hail storm in May is a common extreme weather event of the area and it occurred once in 2017. Due to this, mango farmers often suffer due to hail storm resulting in heavy fruit damage and fruit drop. Often, the crop will be sold at a lower price compared to tamarind. An economic analysis was made among five farmers each under mango and tamarind orchard. An average mango farmers, mango farmers got Rs 52500 per ha per annum as compared to Rs 65250 per ha per annum in tamarind. Due to the fact that tamarind is less susceptible to hail storm and relatively more suitable to the locality based on soil site parameters, farmers prefer tamarind than any other dry land orchard crops. Therefore, tamarind (fig-5) is recommended under NICRA project due to its sustainable yield and income for rainfall abnormalities associated with hail storm.

Table-1: AAS issued and amount saved per AAS farmer over 5 years (2011-16)

Year	AAS issued	Successful AAS	Percent	Amount Saved (Rs)	No. of Farmers	Amount saved(Rs.) / farmer
2011	104	61	58.7	90,599	60	1,510
2012	103	68	66.0	1,60,320	158	1,015
2013	101	72	71.3	9,06,203	125	7,250
2014	103	59	57.3	7,98,550	84	9,507
2015	104	56	53.8	13,47,885	57	23,647
2016	101	63	62.3	4,41,015	66	6,682
Total	616	379	61.5*	37,44,572	550	6,808*

Note: * indicates average values

Table-2: Benefit B:C ratio of AAS and non-AAS farmers' over 5 years (2011-2016)

Name of the crop	B:C ratio	
	AAS Farmers(48)	NON-AAS Farmers(48)
Field crops	2.59	1.57
Vegetable crops	2.62	1.61
Flower crops	2.20	1.42
Fruit crops	2.61	1.72

Table-3: Impact of weather based agro advisories in grapes during 2015-16 and 2016-17 (average of two years, n=10).

Groups of farmers	Productivity (t/ha)	cost of production Rs/ha	Gross income Rs/ha	% increase in income	Reduced cost (Rs/ha)	Additional return (Rs/ha)	B:C ratio
Non AAS farmers	28.50	1,15,000	6.27000	-	-	-	5.45
AAS farmers	35.00	95,000	8,75,000	149	-20,000	2,68,000	9.21

Note: Market Rate of grapes ranged from Rs. 22,000 to Rs. 40,000 per ton. Reduced cost was due to savings in irrigation, pesticides spraying, pruning and labour.

Table-4: Partial Budgeting to assess the benefits of climate resilient system of field bean-horse gram +niger double cropping against single cropping of finger millet during 2016 drought (n=10)

Sl no	Debit column (Rs./ha)	Credit Column (Rs./ha)
1	Additional cost for seeds, labour and pesticides Rs.33,000	Reduced cost Rs0
2	----	Additional returns from vegetable field bean, niger and horse gram Rs 67,500
3	Total additional cost Rs33,000	Total additional gain Rs 67,500
4	Net gain = Rs.67,500 - Rs.33,000 = Rs.34,500/ha	

Table-5: Productivity enhancement through climate resilient system of field bean- horse gram double cropping system against single cropping of finger millet during 2016 drought (n=10).

Cropping system	Productivity (q/ha)	Income (Rs/ha)	% increase in income	Additional cost (Rs/ha)	Additional return (Rs/ha)	Additional return to the additional cost
Finger millet	Grain 7.00 Straw 12.00	35,500	-	-	-	
Field bean-finger millet double cropping system	Field bean harvested for vegetable 20.30 Finger millet grain 0.00 Finger millet Straw 2.30	84,650	138	31500	53,150	1.69
Field bean-horsegram + niger double cropping system	Field bean harvested for vegetable 20.30 Horse gram 3.00 Niger 1.10	1,00,500	280	33000	67,500	2.04

Note: Market rates used for calculation - Vegetable field bean Rs.4,000/q, finger millet grain= Rs.2,500/q, finger millet straw= Rs.1,500/q, horse gram = Rs.3,500/q, niger= Rs.8000/q,

* Input cost =finger millet = Rs 35/kg, horsegram= Rs 60/kg, field bean = Rs 140/kg, niger = Rs 100/kg

** Farmers who have harvested field bean for seeds instead of vegetable pods got 5.1 quintal per ha (the rate of field bean seeds = Rs.8,000/q)

Table-6: Cost of cultivation and income of climate resilient variety (GPU-28) as compared to long duration varieties (n=10)

Finger millet variety	Productivity (q/ha)	Income (Rs)	Cost of cultivation/ ha	Net Income (Rs)	Additional return/ ha
Long duration varieties (MR-6, Indaf -8, L-5)	15.62	62,500=00	43,500=00	19,000=00	-
Short duration varieties (GPU-28)	25.00	77,500=00	42,000=00	35,500=00	16,500=00

Note: Market values: Finger millet grain Rs 2300/- per quintal, straw = Rs 1500 per quintal

Table-7: Double cropping/intercropping systems with finger millet adopted by the NICRA farmers

Intercrop/ Double cropping	Area in ha.	No. of NICRA farmers	Average Income (Rs/ ha)
Finger millet + pigeonpea (8 :1)	3	7	75,200
Finger millet + groundnut (8 :1)	3	5	70,100
Cowpea - finger millet	2	5	51,500
Sesamum - finger millet	2.5	6	55,400
Field bean - horse gram	1.5	7	60,000
Total/Average	12	30	62,440
Farmers without NICRA (Traditional system)	12	30	50,500

* Note: Traditional system include 9 crops mixed with finger millet and is called locally as akkadi/ nava danya system



Fig-1: Bumper crop of finger millet in 2017 due to the resilient variety- GPU-28



Fig-2: Close up view of coffee flower clusters and pollination through insect



Fig-3: Rain gun/ sprinkler for simulating rain as blossom shower from seepage pond in coffee



Fig-4: Abnormal rainfall impact on coffee



Fig-5: Tamarind- sustainable income generating agri-horti system against hail storm and drought even on gravelly sandy loam soils

20. Drought Management Strategies For Northern Karnataka

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1. Background

Karnataka state forms the South Western part of the Deccan Peninsula and lies between 11.5° and 18.6° North latitude and 74.0° and 78.4° East longitudes. The State has about 120.59 lakh hectares of cultivable area out of total geographical area of 190.50 lakh hectares, accounting for 63.30 per cent. Out of the gross cultivated area, the area under irrigation was 30.89 lakh hectares (26.5%). Northern Dry Zone of Karnataka is biggest zone in the Karnataka, has nearly 56 per cent of the soils are shallow to very shallow, possessing very low available water holding capacity and growing period of fewer than 90 days. Annual rainfall is low and erratic (LPA of 594 mm and CV of 30%). Droughts generally occur twice in a five year period, while the severe droughts that persist for 3-4 years (1876, 1906, 1942, 1972 & 2002) occurred once in 30 years. However, such event has occurred within 15 years (2014-16) on the last occasion.

2. Drought management strategies adopted

- Terrace level practices
 - Graded bunding
 - Zingg conservation bench terrace
- Inter terrace land management practices
 - Conservation furrow
 - Compartment bunding
 - Ridges and furrows
 - Wider row spacing and repeated intercultivation
- Water harvesting and recycling
- Contingent crop planning for aberrant weather

3. Implementation of technology

The inter-disciplinary team comprises Agronomy, Agricultural Engineering, Soil Science and Plant Breeding by conducting on-station research at Regional Agricultural Research Station (RARS), Vijayapura and also on-farm demonstrations through participatory mode were carried out under the following projects.

1. National innovations in climate resilient Agriculture (NICRA) in the Kawalagi village.
2. Advanced Research and Upscaling of Dryland Technologies in Northern Dry zone of Karnataka at Honwad (Vijayapura district), Hullur (Gadag district) and Hansanur (Bagalkote district) under GOI, DARE, New Delhi project.
3. Upscaling of focused dryland technologies through participatory mode in the Mannur, Nandihal and Balaganur villages of Vijayapura district under CGIAR-DS project.
4. Dry Farming Technologies through farmers participatory approach at Honwad village of Vijayapura district (GoK project).
5. Rain Water Harvesting and Ground Water Recharge in Vijayapur Campus (CGWB project).

After successful implementation On Farm Demonstrations, the following technologies transferred through line department to the farmers.

4. Impact of implemented technology in minimising losses and improve coping capacity of the community

1. Terrace level practices

A. Graded bund for Medium to Deep black soils

Medium and deep black soils are usually associated with low infiltration rates and are frequently encountered with surface runoff, soil loss and delayed wetting of the soil profile. It is therefore essential to lay out the land into graded bunds. These structures are recommended for medium to deep black soils of more than 45 cm depth with permeability of less than 8 mm per hour in areas of medium to low rainfall. Graded bunds are laid out at a vertical interval of 1.0 m with a bund section of 0.6 to 1.5 m² and stabilized through vegetation.

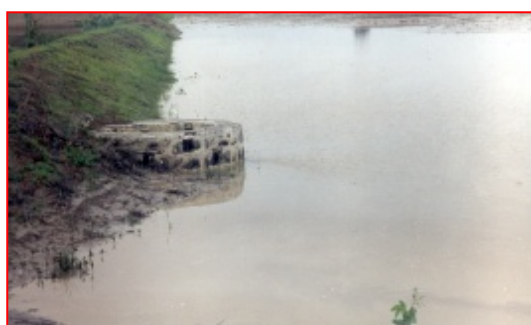
Performance: Crop yields at different locations were increased due to adoption of graded bunds. The yield increase over



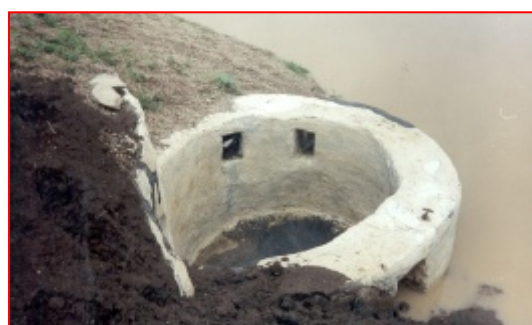
control was to the tune of 128 per cent in *rabi* sorghum (Vijayapura), 34.3% in chickpea (Raichur), 27.8% in sunflower (Kalaburgi), 21.9% in blackgram (Bidar) and 89.5% in chickpea and 28.8% in safflower in chickpea + safflower intercropping system.

B. Zingg Conservation Bench Terraces in Medium to Deep black soils

In this practice, 1/3 to 1/4 area on the upstream side of the bund are leveled. The rainwater is allowed to spread uniformly along the bund in leveled portion. The pressure on the bund is reduced. The cost involved is Rs.15000 per ha for zingg conservation bench terrace. The bunds have to be raised at every 4-5 years interval.



Zingg conservation bench



Drop inlet spillway for excess water

Performance: Double cropping was made possible due to this modified practice in the farmers' fields. The extent of increase in the yield of different crops ranged between 39 to 139%. Adoption of this technology enhanced the productivity of *rabi* sorghum, sunflower, greengram and pearl millet by 39, 82, 113 and 139%, respectively over a period of 5 years. The yield advantage is more visible during deficit rainfall period.

II. Inter terrace land management practices

A. Conservation Furrow as an in situ Moisture Conservation Practice

A conservation furrow is opened at every 8th row in closed spaced crops and every alternate row in wide spaced crops by using ridger or wooden plough. While in the intercropping systems like pearl millet + groundnut (2:4), pigeonpea + groundnut (2:4), furrow are opened in between the lines of pearl millet or pigeonpea. Cost of opening conservation furrow is Rs. 1200/ha.



**Conservation furrow in
pigeonpea + greengram (2:4)**



**Conservation furrow in
Chickpea**

Performance : The rain water stands in the furrows and provides more time to infiltrate in to the soil. Stored moisture will be available for the crops. Crops can overcome the effect of dryspell. There was an increase in the yield of greengram, groundnut, pearl millet and pigeonpea to an extent of 25 to 30 per cent.

B. Compartment Bunding in Black soils

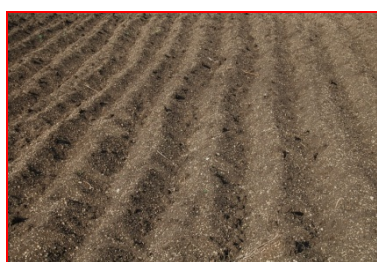
After receipt of few showers in June-July, land is harrowed to remove germinating weeds. Then compartment bunds are formed using bund former. The size of the bunds varies from 3 m x 3 m to 4.5 m x 4.5 m depending on the slope. These bunds are retained till the sowing of *rabi* crops.



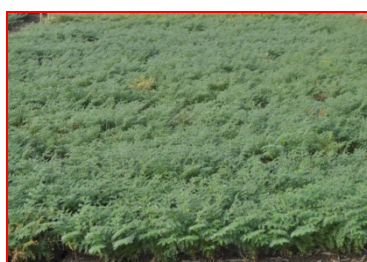
Performance: Compartment bunds help in conserving soil moisture. The rainwater is conserved in the bunds where it falls as the bunds provide more opportunity time for water to infiltrate into the soil. Adoption of compartmental bunding in *rabi* sorghum, sunflower, safflower and chickpea gives yield advantage of 40, 35, 38 and 50%, respectively over no compartmental bunding or flat planting.

C. Ridges and Furrows as an *in situ* Moisture Conservation Practice

After receipt of few showers in June-July, land is harrowed to remove germinating weeds. Then ridges and furrows are formed using ridger at an spacing of 45 cm across the slope. These ridges and furrows are retained till the sowing of *rabi* crops. Further ridges and furrows serves as drainage lines under excess water filtration.



Ridges and furrows



Chickpea in Ridges and furrows plot



Chickpea in control plot

Performance: Ridges and furrows help in conserving soil moisture. The rainwater is conserved in the furrows where it falls as the ridges and furrows provide more opportunity time for water to infiltrate into the soil. Adoption of ridges and furrows in *rabi* sorghum, sunflower, safflower and chickpea resulted in yield advantage of 51, 38, 46 and 53%, respectively over control or flat planting.

III. Water harvesting and recycling

A. Farm pond for rain water harvesting in black soils

Rain water is harvested in the individual fields; the size of the pond depends on the catchment area of the pond. In the zone, where normal rainfall is around 600 mm, by considering two filling, the runoff yield of 150 m³/ha is considered for the determining the size of the pond. In black cotton soil, the side slopes of 1.5: 1 is recommended. The inlet is designed as the broad crested weir, wherever feasible, inlet cum outlet structure should be constructed. Lining is not required in the black cotton soils, however in red soils and other soils lining is required. For lifting the water, low head high speed, 1.5 hp (3000 rpm) pump and/or 1.2 hp surface solar pumps can also be used. As an evaporation retardant, the steryl alcohol was found promising. Farm pond water use efficiency could be increased by using the sprinkler irrigation system.



Farm pond

Performance: Experiments for many years showed that the water harvesting and recycling is successful in the Northern Karnataka. It is found that by giving one supplemental irrigation of 5cm depth at critical stages by surface irrigation method, the yield increased to the tune of 20-30 % in *kharif* crops and it was 30-80% in *rabi* crops. In Integrated Farming System (IFS) also, farm pond played the vital role in increasing the productivity of the land.

IV Contingency crop planning for aberrant weather

The Northern Dry zone of Karnataka (Zone-3) covers 35 taluks. Out of total cultivable area of 41.90 lakh ha, the rainfed area is 32.30 lakh ha.

Soils: The soils are shallow to deep black clay in major areas and 20% red loamy sandy soils. The annual rainfall ranges from 464.5 to 785.7 mm and about 52% of the annual rainfall is received during *rabi* season.

Crops: The important crops grown here are bajra, pigeonpea, greengram, sunflower, *rabi* sorghum, chickpea, maize, groundnut, cotton, wheat, paddy and sugar cane.

Normal onset of monsoon favourable for *kharif* crops

- Take up sowing of the crops in June in light soils viz., groundnut (bunch and spreading), bajra, redgram, *Kharif* sorghum, setaria, hybrid sorghum and other crop mixtures like *Kharif* sorghum + redgram (2:1), groundnut + redgram (3:1), setaria + redgram (2:1), bajra + redgram (2:1). Similarly pulse crops in light retentive soils may be taken up.
- In *rabi* areas i.e., medium black soils, sow greengram/blackgram, as a first crop to be followed by safflower/*rabi* sorghum/bengalgram/wheat.
- When the land is kept fallow (deep black soils) for *rabi* crops, take up compartment bunding or scooping or ridges and furrows or tied ridges for better soil and moisture conservation. Take up harrowing after each rain and convert the plot into ridges and furrows or compartment bunds, which help in controlling weeds and conserving soil moisture.

Normal onset of monsoon, but dry spells soon after germination

- Give protective irrigation for the crops sown wherever possible.
- Ratoon Bajra/sorghum for rejuvenation after rains.
- For crops like Groundnut, take up Urea spray immediately after rains for quick revival, wherever possible.
- When the sown crops completely wither, go for sowing of setaria, dolichos, horsegram, mothbean, cowpea and sunflower soon after rains.

No normal rains in June but onset of rains in July

- Sow groundnut (spreading), sunflower and setaria, in *kharif* area.
- Sow entire redgram, sesamum, cowpea/horsegram in light soils.
- In *rabi* areas do not sow greengram or blackgram since it will delay *rabi* sowing.
- Harrowing to be done after each shower to remove weeds in *rabi* areas.
- Take up sowing of rainfed cotton by end of July.

Normal rains in August

- Complete sowing of dryland cotton before the mid of August. Grow herbacious cottons in place of hirsutums.
- Sunflower, sesamum, redgram, setaria and horsegram should be sown in light soils.
- Plant castor on contour bunds also.
- Take up relay cotton in groundnut in medium black soils.

Normal rains in September

- Complete sowing of *rabi* sorghum by mid of September in medium black soils of Northern taluks of Bijapur district. In the remaining taluks *viz.*, Bagalkot, Hungund, Bilagi, Mudhol and Muddebihal complete sowing of *Rabi* sorghum by first week of October. Early sowing of *Rabi* sorghum by 2 weeks compared to conventional sowing in other districts is preferred.
- Sow Safflower as an entire crop before the end of September.
- Sow Sunflower upto third week of September.

Sowing in October

- Continue sowing of *Rabi* sorghum till October.
- Follow mixed cropping of *Rabi* sorghum + bengalgram in 2:1 row proportion in Bijapur area.
- Sow Safflower and bengalgram as mixed crops.
- Increase the area under safflower.
- Sow bengalgram and safflower in 3:1 row proportion for higher returns.
- Wheat may be sown till the end of October in retentive soils.

- Top dress Rabi sorghum with 10-15 kg N per hectare if adequate moisture is available in the soil.

Execution of the technique(s) developed through research and development in the Operational Research Projects

Under the different Ad-hoc projects, techniques developed through the research and development at the main centre were implemented in seven villages. Further, the various activities carried out under various projects are discussed in the following paragraphs.

I. Advanced Research and Upscaling of Dryland Technologies in Northern Dry zone of Karnataka (DARE-GoI)

Under the DARE, GoI, SFC funded project, during 2013-15, three villages Honwad, Hansbhavi and Hullur villages were selected from the Vijayapura, Bagalkot and Gadag districts respectively. SWC structures (bunds, farm ponds) were constructed in 1,000 ha area of project villages and also other dry land practices were demonstrated. About 15-20% increase in yield was observed in treated areas over the conventional practices. The various activities carried out under the project are tabulated below.

Table: Effect of SWC structures on crop productivity (kg/ha) in ORP villages

Crop	Outside watershed	Watershed		Per cent increase of demonstration over non demo in watershed	Per cent increase of watershed demonstration over outside watershed
		Non demonstration	Demonstration		
Bengalgram	1350	1585	1710	7.88	26.66
Sunflower	961	1130	1283	13.53	33.50
Sorghum	1396	1510	1652	9.40	18.33
Safflower	920	1088	1193	9.65	29.67
Wheat	1337	1508	1680	11.40	25.65

In addition to this, the above listed technologies have been demonstrated in the following projects

1. National innovations in climate resilient Agriculture (NICRA) in the Kawalagi village.
2. Upscaling of focused dryland technologies through participatory mode in the Mannur, Nandihal and Balaganur villages of Vijayapura district under CGIAR-DS project.
3. Dry Farming Technologies through farmers participatory approach at Honwad village of Vijayapura district (GoK project).
4. Rain Water Harvesting and Ground Water Recharge in Vijayapur Campus (CGWB project).

5. Short comings in implementation of available technologies if any

I.Terrace level practices:*Graded bund for medium to deep black soils and Zingg conservation bench terrace.*

High initial cost, demands the technical skill and awareness among the farmers

II.Inter terrace land management practices: *Conservation furrow, Compartment bunding and Ridges and furrows*

Sufficient number and timely non availability of appropriate equipments(bund farmer , BBF maker, etc)

III.Rain water harvesting and recycling

High initial cost, demands the technical skill and awareness among the Farmers

6. Recommendations for improvement/correction of the available technology/strategy:

I. Terrace level practices: Graded bund for medium to deep black soils and Zingg conservation bench terrace.

- This technology may be converged with the watershed programme, RKVY, MGNREGA and the Karnataka government's special programme Krishibhagya.
- Capacity building of the stake holders

II. Inter terrace land management practices: Conservation furrow, Compartment bunding and Ridges and furrows

- The practice is accepted by more farmers in dry regions as the impact of the practice is more during sub-optimal rainfall years. It can be converged with RKVY, NFSM and Krishibhagya programmes.
- Capacity building of the stake holders
- Implements/equipments can be made available through custom hire centre

III. Rain water harvesting and recycling

- In the ongoing watershed development programmes, the farm ponds are being constructed in the farmers' fields. This technology may be up scaled through the Watershed Development Department, MGNREGA and Krishibhagya programmes.

IV. Contingent crop planning for aberrant weather

- Improvement in the weather forecasting
- Different short duration seeds made available to the farmers

7. Best practices in any of these sectors (Drought preparedness, Monitoring, Mitigation and Response and relief strategies).

A. Drought preparedness

- i. Terrace Level practices
- ii. Inter terrace land management practices
- iii. Water harvesting

B. Drought mitigation

Problem/s	Technology
Variation in onset of monsoon	Contingency crop plan with suitable crops and varieties to be sown at different times of the rainy season.
Early season drought	➤ Thinning 30-35% of the population, Weeding ➤ Repeated intercultivation to form soil dust mulch ➤ Opening of conservation furrow at 15-20m ➤ Provide Supplemental irrigation from the farm pond ➤ 1% potassium nitrate foliar spray after receipt of rains ➤ 2% urea foliar spray after receipt of rains
Mid season drought	Removal of every 3rd row; Weeding; Harvest bajra, sorghum for fodder purpose and allow for rationing; Removal of weak seedlings; Repeated intercultivation to form soil dust mulch; Opening of conservation furrow at 15-20m; 1% potassium nitrate foliar spray after receipt of rains; 2% urea foliar spray after receipt of rains; Provide Supplemental irrigation from the farm pond
Terminal drought	➤ Repeated intercultivation to form soil dust mulch ➤ Harvest the crops at physiological maturity ➤ Provide Supplemental irrigation from the farm pond

21. Strategies For Drought Management in Horticulture Crops In Karnataka

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Introduction:

Drought is a weather-related natural disaster and is a recurrent feature of the climate. It has an impact on agricultural production and reduces life expectancy and the economic performance of large regions. It occurs in virtually all climatic zones, and its characteristics vary significantly among regions. Drought differs from aridity in that drought is temporary; aridity is a permanent characteristic of regions with low rainfall. Drought is an insidious hazard of nature. It is related to a deficiency of precipitation over an extended period of time, usually for a season or more. This deficiency results in a water shortage for some activity, group, or environmental sector. Drought is also related to the timing of precipitation. Other climatic factors such as high temperature, high wind, and low relative humidity are often associated with drought. Drought is more than a physical phenomenon or natural event. Its impact results from the relation between a natural event and demands on the water supply, and it is often exacerbated by human activities.

The various types of droughts are listed below.

- a) Meteorological drought:** Meteorological drought refers to 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. Based on the data on daily rainfall information, temperature, humidity, wind velocity and pressure, and evaporation the meteorological drought can be assessed.

- b) Agricultural drought:** 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. Data sets required to assess agricultural drought are soil texture, fertility and soil moisture, crop type and area, crop water requirements, pests and climate.
- c) Hydrological drought:** Hydrological drought refers to a persistently low discharge and/or volume of water in streams and reservoirs, lasting months or years. Hydrological drought is a natural phenomenon, but it 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. Data sets required to assess hydrological drought are surface-water area and volume, surface runoff, stream flow measurements, infiltration, water-table fluctuations, and aquifer parameters.
- d) Socioeconomic drought:** Socioeconomic definitions of drought associate the supply and demand of some economic good with elements of meteorological, hydrological, and agricultural drought. It differs from the other types of drought in that its occurrence depends on the processes of supply and demand. The supply of many economic goods, such as water, forage, food grains, fish, and hydroelectric power, depends on the weather. Due to the natural variability of climate, water supply is ample in some years, but insufficient to meet human and environmental needs in other years. Socioeconomic drought occurs when the demand for an economic good exceeds the supply as a result of a weather-related shortfall in water supply. Data sets required to assess socioeconomic drought are human and

animal population and growth rate, water and fodder requirements, severity of crop failure, and industry type and water requirements.

1. Background to draught in Karnataka:

Karnataka is one of the Southern States in India covering an area of 1.92 lakh sq.kms. with varied topography. Though it has a cultivable area of 1.27 lakh sq.kms, only 20 per cent of it is under irrigation. Arid regions which receive less than 750 mm of rainfall are drought prone and constitute more than 2/3rd of the geographical area of the state. The study of the Directorate and Statistics (1984) on the rainfall-data over 80 years indicated about 20 drought-years and the highest number of drought years were experienced by Mandya, Kolar, Tumkur, Chitradurga and Mysore districts. As a result, droughts have become annual features in several parts of the State. Of the past 15 years, 13 have been drought years in Karnataka. 2017 doesn't bode too well either, according to the Karnataka State Natural Disaster Monitoring Centre (KSNDMC). The worrying scenario doesn't end there. KSNDMC authorities also state that after desert state Rajasthan, Karnataka has the most extent of land ravaged by drought, with 80 per cent of its land prone to drought. "Since 2001, state witnessed 13 years of drought. During 2016, of the 176 taluks in Karnataka, 160 were declared as drought hit, Karnataka state witnessed 26 per cent deficit rainfall. Malnad belt, which plays an important role in recharging dams as a catchment area, saw 34 per cent rain deficit which is more than the state average. Karnataka is one of the prominent horticulture state in the country and a variety of horticultural crops are grown by the farmers in different parts of the state. The following strategies can be followed by the farmers to overcome the difficulties posed by the drought.

2. Strategies:

➤ Crop Selection:

Some of the fruit crops like mango, guava, fig, ber, annona species & underutilized fruit crops like Jack fruit, karonda, phalsa, wood apple and vegetable crops like cowpea, cluster bean, chilli, drumstick, tomato, cucurbits, brinjal, okra are

suitable for rain-fed cultivation. Among these, legume vegetables can be recommended for contingency crop-planning in an eventuality of late monsoon rains. Varieties having good root system and capacity to recoup after the alleviation of stress need to be selected. Depending upon situation, it is recommended to use short duration varieties.

➤ ***Suitable rootstocks:***

Environmental stresses such as water deficiency, salinity, high water level and low temperature affect plant growth and decrease horticultural crops productivity. It is important to improve stress tolerance of the crop plant to increase crop yield under stress conditions and reduce the yield gaps by increasing plant crops tolerance to stresses by use of tolerant rootstocks in different horticultural crops.

Examples:

Grape: Dogridge, Saint George, Ruggeri, 110 R, SO4, 1103 Paulsen, GRN-3, GRN-4

Citrus: Rangpur lime, Marmalade orange, Rough lemon, Sour orange

Rootstocks technology namely Dogridge alone revolutionized the grape cultivation with 10-15 % higher yield and quality improvement.

➤ ***Canopy Management:***

Pruning of unwanted branches is essential in different fruit crops like guava, fig etc. to reduce the transpiration loss and inturn will reduce the uptake of soil moisture.

➤ ***Improved method of Seedling production:***

Improved method of seedling production such as Protray (Tomato, Brinjal, Chilli, Cauliflower, Cabbage, Turmeric, Ginger) grown seedling using coco peat, nylon net protection and bio-fertilizers/bio-pesticide inoculation at nursery stage has good potential for obtaining sturdy, uniform and healthy seedlings. These seedlings when transplanted

in the main field will establish better with less root damage and its field stand is better in overcoming biotic and abiotic stresses particularly during water stress conditions.

➤ ***Adoption of soil and moisture conservation techniques:***

Contour cultivation, contour strip cropping, mixed cropping, tillage, mulching, zero tillage, microcatchments are some of the agronomical measures for the *in-situ* soil moisture conservation and are widely adopted in crops like mango, guava, fig, ber, annona species & underutilized fruit crops like Jack fruit, karonda, phalsa, wood apple and vegetable crops like cowpea, cluster bean, chilli, drumstick, tomato, cucurbits, okra. Mechanical measures like contour bunding, graded bunding, bench terracing, vertical mulching etc. also need to be followed for effective soil and moisture conservation in dry lands. Another technology for efficient utilization of runoff is water harvesting & recycling. Rainwater harvesting includes collecting runoff water into dug out ponds or tanks in small depressions, gullies and into storage dams of earth or masonry structures. Rain water harvesting is possible in areas having rainfall as little as 500 to 800 mm. Depending on the rainfall and soil characteristics, 10-50 % of the runoff can be collected in farm pond. Surface run off thus collected in a farm pond can be used to provide protective irrigation in the period of prolonged dry spell through microirrigation techniques.

➤ ***Enhancing soil organic matter content:***

Constant efforts must be made to improve the soil organic carbon. Incorporation of crop residues and farm yard manure to soil improves the organic matter status (0.2 to 0.3%), improves soil structure and soil moisture storage capacity. Organic matter content of the soil can also be improved by following alley cropping, green manuring, crop rotation and agro forestry. Vegetable being short duration crop and having faster growth phases, the available organic matter needs to be properly composted. Vermi composting can be followed for quicker usage of available organic matter in the soil and improving the soil moisture holding capacity.

➤ ***Foliar nutrition:***

The foliar application of nutrients during water stress conditions helps in the better growth by quick absorption of nutrients. The spraying of K and Ca induces drought

tolerance in vegetable crops (Tomato, Brinjal, Chilli, Cauliflower, Cabbage, Onion and leafy vegetables). Spraying of micronutrients and secondary nutrients improves crop yields and quality.

➤ ***Adoption of drip irrigation:***

Drip irrigation has proved its superiority over other conventional method of irrigation in horticulture due to precise and direct application of water in root zone. A considerable saving in water, increased growth, development and yields of fruits and vegetables and control of weeds, saving in labour under drip irrigation are the added advantages. Drip irrigation can be adopted in fruit crops and also to all vegetable crops including closed spaced crops like onions and beans. The saving in water is to the tune of 30-50 % depending on the crop and season. Generally inline drip laterals having emitting point spaced at 30cm distance and emitting at the rate of 2LPH is selected for vegetable crops. In crops like chilli, brinjal, cauliflower and okra paired row planting is practiced and one drip lateral is used for two crop rows.

➤ ***Moisture saving methods under limited water resource conditions:***

The following methods may be adopted under limited water conditions to save water:

- a) **Water saving irrigation method:** Under limited water situations, water-saving irrigation methods like alternate furrow irrigation or widely spaced furrow irrigation and drip irrigation systems can be adopted. Studies conducted on methods of irrigation in capsicum, tomato, okra and cauliflower indicated that adopting alternate-furrow irrigation and widely-spaced furrow irrigation saved 35 to 40 per cent of irrigation water without adversely affecting yield.
- b) **Mulching Practices in Ornamental crops & Vegetable Production** - The technique of covering the soil with natural crop residues or plastic films for soil and water conservation is called mulching. Mulching can be practiced in vegetable crops like Chilli, Tomato, Brinjal etc. by using crop residues and other organic material available in the farm. Recently plastic mulches have come into use due to the inherent advantages of efficient moisture conservation, weed suppression and maintenance of soil structure. Wide variety of ornamental

flower crops like Chrysanthemum, Marigold, Crossandra, Jasmine, China aster, Gailardia etc can be successfully grown using mulches. In addition to soil and water conservation, improved yield and quality, suppression of weed growth, mulches can improve the use efficiency of applied fertilizer nutrients and also use of reflective mulches are likely to minimize the incidence of virus diseases. For vegetable production generally polyethylene mulch film of 30 micron thick and 1 to 1.2 m width is used. Generally raised bed with drip irrigation system is followed while laying the mulch film.

➤ ***Wind breaks, hedges and intercropping:***

To overcome the adverse effect of high temperature and dry winds, tall growing trees like Polyalthia longifolia, Casurina equisetifolia, Erythrina indica, Eucalyptus ciirdors, Gravilla robustus, Dalbergia sisso, Syzygium cumin, Mangifera indica, Averhoa carambola, Bambusa spp. need to be planted all along the boundary of the farm. Inter cropping of vegetable crops of the area can be practiced in orchards during summer months. Maize/ Sorghum can be grown all along the border of the plot to mitigate the effect of desiccating winds.

The presence of windbreaks is usually considered positive in mitigating the evapotranspiration (ET). So even with a short windbreak of 4 feet (1.2 m) high, can protect plants from dry winds for 40 feet (12 m) or more. A taller windbreak 20 feet (6 m) high will create a 200 foot (60 m) zone of warmer conditions, enough to protect the entire field by changing the microclimate and probably your neighbor's field as well.

➤ ***Growing vegetables under protected cultivation:***

In peri-urban regions where climate does not favour year round production of crops in the open field, vegetable production can be taken up in protected environment. Protective structure is a facility to protect crop from biotic and abiotic constraints. Structures for protected cultivation include green houses, plastic/net houses and "tunnels". Commonly used protected structures are polyhouses and net or shade houses. Rain-shelter is a simple structure covered with polyethylene sheet which helps in producing the crops which are affected by excessive rainfall. The productivity of tomato, onions and melons are adversely affected in the event of high rainfall due to

difficulty in managing the foliar diseases, lack of proper soil aeration and drainage and also depending on the nature of crop physical damage of the foliage and flower drop. Net house cultivation and shade net cultivation provide better microclimate especially during summer in minimizing the high temperature effect and improving the relative humidity. The productivity of tomato, French bean and capsicum can be improved during high temperature period by using net/shade net on the top.

3. Implementation of technology:

Community based water management technology: Asia's largest drip irrigation project Ramthal

The project is based on the unique concept of integrated micro irrigation. As per which, water is to be delivered directly using HDPE / PVC piping network to irrigate about 60,000 acres. About 20,000 farmers in Hungund taluk in Bagalkot district are benefited from this project. Whereas conventional irrigation system could have only irrigated 30,375 acres, the use of drip irrigation has almost doubled the area of irrigated land by an additional 29,625 acres.

Compared with the traditional method of canal irrigation where about 60% of water is lost in transportation, evaporation and seepage, integrated micro irrigation involves use of closed piping networks right from the source to the root zone of crops. Thereby saving enormous amount of water and causing a substantial increase in crop yields.

- The project uses just 2.77 TMC of water needed to irrigate 60,000 acres
- Has enabled farmers to grow high value commercial crops
- Drip irrigation saves 50% more water than conventional system

Water harvesting structures: Krishi Hondas (farm ponds).

The Krishi Bhagya programme was launched to secure farmers incomes by promoting on-farm rainwater conservation and encouraging efficient use of water

through adoption of modern technologies. “The scheme is aimed at helping farmers to take up sustainable dry land farming which will lead to their economic development.”

“Keeping in view of the chronic problems faced by farmers in cultivating dry land mainly due to vagaries of monsoon, the government introduced the scheme which is aimed at harvesting rainwater to protect crop during a crucial time through Krishi Hondas (farm ponds).”

4. Impact of implemented technologies in minimizing losses and improve coping capacity of the community

Community based Krishi Bhagya programme launched in 2014, it has revolutionized the face of dry-land-farming by reducing the dependency on rain. About 1.6 lakh ponds have been created to harvest and conserve the rainwater. To prevent water seepage into the ground, these ponds are lined with high-density polyethylene sheets. A small diesel operated motor pumps water into the micro irrigation system in the field. Depending on the size, these ponds can hold 1.6 lakh litres to 8 lakh litres of water in the tanks. From this scheme, farmers will have the ability to irrigate standing crops as and when required in the entire cropping season. The Krishi Bhagya programme has improved crop productivity by up to 25-30 per cent.

Sharanappa Hadli, a farmer from Belavanaki village in Ron taluk, said the ponds dug under Krishi Bhagya helped him have sufficient water for crops. He further said, “I have been farming for the last 30 years. Earlier, I was incurring a loss of Rs. 10-15 lakhs. Last year, I made a profit of Rs. 30 lakhs.”

Under the Krishi Bhagya programme, over 3.9 lakh farmers have adopted drip and sprinkler irrigation systems, covering an area of 4 lakh hectares. The drip and sprinklers have been distributed at 90 per cent subsidy for farmers holding up to 5 acres and at 50 per cent for farmers with over 5 acres. To encourage farmers to grow high-value produces such as flowers and exotic vegetables, 2,546 polyhouses have been constructed. In the last four years, the government has provided Rs. 1,121 crores

towards this flagship programme. In the current financial year, the plan is to cover an additional 1.8 lakh hectares at an estimated cost of Rs. 375 crores.

The success of the scheme in meeting its set objectives of improving incomes, saving water and increasing productivity has received national attention. “The novel scheme of the government has not only won the appreciation of the Union government, which had sought all details of the scheme, but has also caught the attention of some of the neighbouring States which are now keen on adopting it.”

5. Shortcomings in implementation of available technologies

Windbreaks are such structures which break the wind-flow and reduce wind speed while shelterbelts are rows of trees or shrubs planted for protection of crop against wind. In the wind erosion areas, windbreaks and shelterbelts are to be planted. They protect the structures. A row of trees and shrubs planted across the winds-direction is the most effective. It reduces the wind speed up to 60-80% on leeward side. The height of tall tree and length of wind break determine the extent of protection provided to soil. Windbreaks and shelterbelts provide the protective shelter against desiccating winds to extent of 5-10 times the height of the tall tree on windward side and up to 30 times on leeward side.

Extension activities has to be strengthened about the maintenance of protected structures to the farming community

Recommendations for improvement/ correction of the available technology/ strategy:

Pusa hydrogel

A water-absorbing hydrogel, which has helped farmers boost crop yields in areas where water is scarce, developed by the Indian Agricultural Research Institute (IARI). Apart from strengthening water absorption, the hydrogel also enhances nutrition absorption by the crops. The hydrogel absorbs a minimum of 350 times its weight of

pure water at temperatures as high as 50 degrees Celsius. Besides having high absorbency at high temperatures suitable for semi-arid and arid regions, it also improves physical properties of soil such as porosity, aggregate stability and hydraulic conductivity. The hydrogel is less affected by salts in the environment, improves germination of seeds, improves root growth, and reduces requirement for fertilizers.

The fragile structure of hydrogels particularly at higher temperatures, high rate of biodegradability, and reduced water absorption capacity at high temperatures have restricted their promotion and use in agriculture. IARI developed a process for preparation of new type of hydrogel that overcomes such limitations. It is now available as a dry powder that is mixed with soil, seeds and very little fertilizer.

The hydrogel is environmentally safe as it degrades completely into carbon dioxide, water and ammonia within a year, according to IARI studies.

“This gel absorbs and retains water for 48 hours and is getting quite popular in farms, and farmers are quite happy. In south India in particular, it has been popular.

Promotion of mulches

A study conducted at University of Horticultural Sciences, Bagalkot on grape & pomegranate on organic & inorganic mulches. Higher percentage of soil moisture (18.76%) at 0-15 cm and 19.54% at 15-30 cm soil depth was recorded in vines mulched with black polythene at different stages. Different mulching material showed different effect on soil temperature. Higher soil temperature was recorded in vines mulched with black polythene (24.96 °C) and highest cost benefit ratio was obtained in vines mulched with sugarcane trash (3.48).

Biochar

Biochar is a charcoal-like substance produced from agriculture and forest wastes which contains 70% carbon. It is used as soil enhancer to increase fertility, prevent soil

degradation and to sequester carbon in the soil. Biochar can store carbon in the soil for as many as hundreds to thousands of years. Biochar is hygroscopic. Thus it is a desirable soil material in many locations due to its ability to attract and retain water. This is possible because of its porous structure and high surface area. As a result this can be used in mitigating water stress.

6. Best strategies for Drought Preparedness, Monitoring, Mitigation, Response and Relief Strategies:

Strategies for Drought Preparedness

- Geographical shifts of agricultural systems
- Climate-proofing rainfall-based systems
- Making irrigated systems more efficient
- Expanding the role of intermediate rainfed-irrigated systems
- Preparation of Agriculture Contingency Plans for districts and sub-district levels
- Identification of drought prone areas, preferably at the sub district level.
- Repair and maintenance of water bodies / tanks / wells etc. to help critical irrigation during dry spells.
- Creation of drought contingency cells at districts to monitor dry spells.
- Land Treatment

Strategies for Drought Monitoring

- Monitoring of seasonal forecasts of IMD and other national / international agencies.
- Provide accurate, timely and integrated information on drought conditions at the level of regions, States and districts.
- Detect drought early; it allows for activation of the drought management plan and evokes both proactive (mitigation) and reactive (emergency) responses.
- Provide information on all the parameters of drought at the relevant spatial scale to the policy-makers, administrators, NGOs, and citizens.
- Prepositioning of inputs like drought resilient variety seeds at strategic locations.

- Develop protocols for various departments to initiate contingency measures with clear allocation of responsibilities.

Strategies for Drought Mitigation

- Selection of suitable crops and varieties
- Improved method of seedling production
- Adoption of soil and moisture conservation techniques
- Enhancing soil organic matter content
- Application of foliar nutrition
- Use of drip irrigation
- Moisture saving methods under limited water resource conditions
- Wind breaks, hedges and intercropping
- Protected cultivation of vegetables
- Rainwater harvesting and Efficient Use
- Use of Pusa Hydrogel
- Organic or Inorganic Mulching
- Anti transparent spray
- Artificial Recharge of Ground Water
- Afforestation
- Rain water harvesting
- Irrigation at critical stages
- Irrigation base on soil moisture availability

Drought Response and Relief Strategies

- Drought Stages and Triggers
- Water Use Reduction Goals
- Water Use Restrictions
- Enforcement Provisions

References:

1. <http://nhm.nic.in/Archive/ADVISORY-FOR-RAINDEFICIT-HORT-CROPS.pdf>
2. <http://nhb.gov.in/pdf/fruits/grape/gra011.pdf>
3. K. V. Peter , Basics Of Horticulture by New India Publishing, pp 341
4. https://www.researchgate.net/publication/311064832_Role_of_Rootstocks_in_Fruit_Production-A_Review
5. <https://laidbackgardener.blog/2016/10/24/gain-a-warmer-microclimate-through-windbreaks>
6. <http://www.fao.org/docrep/009/a0100e/a0100e07.htm>
7. https://www.researchgate.net/publication/302940377_Effect_of_Alley_Cropping_on_soil_Aggregate_Stability_of_a_tropical_alfisol
8. <http://www.climatetechwiki.org/technology/biochar>
9. <https://www.sciencedirect.com/science/article/pii/S221209471400019X>
10. http://nidm.gov.in/pdf/manuals/drought_manual.pdf

22. Water Resources of Peninsular India, Equitable Distribution of Water and Drought Management Strategies

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1. The fascinating story of the development of the fluvial geomorphology and landscapes of the present day Karnataka involve many varied geological factors that played a role. These include and date back to the break-up of the Gondwana Super continent some 80 million years ago, the 6400 km long northward journey of the Indian plate (fig.1) before its collision with the Eurasian plate, the outpouring of the voluminous Deccan lavas signaling a major phase of volcanic activity resulting uplifted plains and the offshore sedimentary basins (fig.2), western ghat paralleling the west coast (fig.3) and finally the subsequent erosional processes in a tectonically active million resulting in multiple scarp surfaces along the west coast of India (fig.4).

What is of interest is the erosive power of the west flowing rivers, especially where they have captured the easterly drainage over the plateau. The Sharavathi and the Kali Rivers are the classical examples of river capture diverting large quantity of water that was originally flowing east, that has now been diverted to west (**Fig.5**), Location map of the Western and Eastern drainage pattern is shown in (**Fig.6**). There are innumerable small and medium rivers as well as streams that originate in Western Ghats (known by the name Sahyadri in early Indian literature and flow for a short distance to the east and then are diverted to the west to join the Arabian sea.

2. Geomorphological aspects of coastal plain, the Western Ghats and the eastern plateau have been described earlier by Radhakrishna, B.P. (1952), Vaidyanadhan (1977), Subramanian (1994) Valdia (2001). Vaidyanadhan, R and SubbaRao, K.V., (2014) W.S. More(1966)]Gunnell (2001). The river system of Peninsular India is consequent to the initial slope of the hill or terrain at the place of origin and guided later by numerous adjustments to tectonic and geological processes over a period

of time and the present morphology is a reflection of the long-lived uplift history of western ghats. The western Ghats are a world-class landform characterize rifting, scrap retreat on a grand scale and the geomorphological and lithospheric after effects of uplift, causing the removal of large quantity of weathered material and their deposition in the Arabian Sea. All the processes, physical, chemical and biological are considered and interlinked within the frame-work of geological time, thus providing a synthesis which has important implication for the distribution pattern of rain-bearing monsoonic winds and soil geography, on which agriculture depends. The land forms of Peninsular India mostly reflect the processes that operated from Eocene to Recent on rock formations ranging in age from Archeans to Quaternary representing all types of variations in topography-high mountains, plateaus, residual hills and coastal plains. The Western Ghats running almost NNW-SSE forms a major water divide. The west- flowing rivers are short and swift draining into the Arabian Sea. The east-flowing rivers of Godavari, Ghataprabha, Malaprabha, Krishna, Tungabhadra and Cauvery traverse through a large part of the State before joining the Bay of Bengal in the east. The North Pennar, South Pennar and Palar rivers flow from the north to south in the southern part of Karnataka due to an east-west divide.

3. Based on the drainage pattern of east and west flowing rivers originating in Sahyadri hill range, a detailed study has to be undertaken, to estimate the total quantity of surface and ground water that can be economically harnessed without disturbing the ecology of Western Ghats. As per one estimate there is a precipitation of 2.99 bcm per km² in western drainage in 13% of the geographic area compared to 0.88 bcm precipitation per km² in 87% of geographic area of eastern drainage of Peninsular India. Out of the total annual water resources of 2.88 bcm in western drainage, how much is discharged by surface flow and how much escapes by underground flow into Arabian sea or Bay of Bengal is not yet to be correctly understood / estimated. Total annual yield of all the rivers of Peninsular India and their estimated quantity of east and west flowing rivers is given in Table 1. The distribution of precipitation and renewable and utilizable supplies of water in Peninsular India is tabulated in Table 2.

Table 1. Annual Yield of Rivers originating in Sahyadri (Source: Vaidyanadhan, R., 2014)

States	Kerala		Karnataka		Goa		Maharashtra		Total
Total Quantity	MCM	78041	MCM	97364	MCM	8570	BCM	163	12254 TCMft
	TMCft	2756	TMCft	3438	TMCft	303	TMCft	5757	
East flowing	MCM	13770	18%	MCM	40781	NIL	BCM	94	5246 TMCft
	TMCft	486		TMCft	1440	42%	TMCft	3320	
West Flowing	MCM	64271	82%	MCM	40781	MCM	8570	100%	6795 TMCft
	TMCft	2269		TMCft	1998	58%	TMCft	303	
Environmental flow, 40% of West flowing rivers	MCM	25705		MCM	22628	MCM	3425	40%	2711 TMCft
	TMCft	908		TMCft	799	TMCft	121		
Excess available for use out of west flowing rivers	MCM	38556		MCM	33956	MCM	5145	60%	4084 TMCft
	TMCft	1361		TMCft	1199	60%	TMCft	182	
							BCM	38	
							TMCft	1342	

Table 2. Resource details of West and East Flowing Water Resources of Peninsular India (Source: Vaidyanathan, A. (2013)

	Area (km ²)		Total Precipitation		Precipitation per km ² in bcm	Renewal supplies (bcm)	Utilizable flow (bcm)	Environmental flow (bcm)
East flowing rivers of the Peninsula	750	87%	660	68%	0.88	230	250	180
West flowing rivers of the Peninsula	112	13%	321	32%	2.88	200	54	67
Total	862		981		3.76	430	304	247

4. With the total planning of entire Sahyadri river system, the Peninsular India can be converted to a prosperous water blessed region. **Science cannot set policy, nor policy can do without science.** The atmosphere, the surface water, soil moisture and groundwater are the four interlinked components that dynamically interact from time scale of days to thousands of years. Balanced erosional and nutrient cycle are vital for survival of life and depends on adapting to hydrological cycle at times of unprecedented demographic change, concentration of population in cities and misuse of surface and groundwater.

Out of the total 12254 TMC ft, water resources of Peninsular India. The annual average yield in seven river basins of Karnataka is estimated at 3438TMCft, However, economically utilizable water for irrigation is estimated at 1695 TMC (State Environmental Report 2003). According to Karnataka State Environment Report – (2007) there are 36,679 tanks in the state with an irrigation potential of 6,84,518 ha (0.6 M ha) and miner irrigation surface tanks with an estimated irrigation potential of about 1.0 M ha. Even though the State has seven river systems and innumerable tanks, 63% of the Karnataka land falls under dry tracts ranking second only to Rajasthan. The State has been identified one of the 16 drought prone States in the country.

5. **Sustainable Agriculture:** As surface water is inadequate, farmers, Industries and cities have turned to ground water to replace their missing supplies. As much as 65% of ground

water in the state may have been pumped to surface depressing Groundwater table appreciably (**Fig.10**) and pumping cannot go on. Groundwater legislation has been enacted, but not effective. Every land owner has a right to pump unlimited quantity of water from bore wells in his ground. Inadequate and sub-optimal pricing of both water and power is promoting the misuse of groundwater. There is a need to move to a situation where ground water can be treated as common property resource. Ground water sources for drinking water often fail due to competition over the same aquifer between public drinking water system, irrigation and industry demand.

Common rules for integrated development of water, minerals, wind power and forest resources should be formulated based on current acts, on short term and long term bases. Macro and Micro basins should be taken as units in the planning of development of natural resources in the context of nature's constraint as implicit in the hydrological cycle and the physical landforms of Karnataka.

Agriculture is the primary user of water with 80% of India's water going towards irrigation. Groundwater extracted through bore wells provides for most of minor irrigation and domestic needs. Agriculture policy with its pronounced tilt towards water guzzling sugarcane is the main cause for India's unsustainable exploitation of groundwater. The combined effect of these policies has led to distortion in States such as Maharashtra and Karnataka where sugarcane which is cultivated on less than 4% of total cropped area takes away almost 70% of irrigation water in these states. Agriculture contributes just 2% of the State's economic output and employs 3% of workers. Farmers are just borrowers of water. The traders of the agriculture produce are the real beneficiaries. Only rich farmers can effectively pump groundwater from deep aquifers and the urban rich can buy extra water for their luxury and safe bottled water for drinking. Over exploitation of ground water has resulted in possible climate change. There should be more funds to recharge ground water in over exploited area by adopting scientific methods of rain water harvesting. India uses two to four times as much of water as used by China/USA to produce one unit of major food crops. There is a need to introduce drip irrigation system and incentive for crop selection in regions to suit agro-climate potential and allocate more water for rural drinking water and sanitation schemes. All major villages should have Underground Drainage System and Water Treatment Plants for re-use water in agriculture and Agro based industries. If we look at the Sugar Cane India Map, you will notice that the farmers of Haryana and Punjab who produce less sugar than Uttar Pradesh, Maharashtra and Karnataka are more affluent and progressive farmers. Scientific cultivation of less-water

consuming crops can also yield better financial returns as compared to water-intensive sugarcane.

6. Social Implications of India's Agricultural System, Groundwater Pumping, Variable Monsoons and Transfer Inter basin of Water

Large, Medium and Small Dams are built by Government with Government expenses and Surface water is produced from these Dams is being utilized by selected few in the downstream (Command Area). On the other hand, in areas outside the command area, farmers invest their own borrowed money at high rate of interest for sinking bore wells to develop agriculture. Only rich farmers can effectively pump groundwater from deep aquifers and the urban rich can buy extra water for their luxuries like car washing, maintain lawns near their residences and use bottled water for drinking purpose. Only Super rich use soft drinks, beer and whisky instead of water to quench their thirst. This rate of over exploitation of Groundwater, will ultimately result in no base flow in major rivers. Fig-11.

7. Important Points For Lay Audiences To Understand About Peninsular India's Water

Identification of water rich and water poor basins and modalities of transfer have been discussed earlier by (i) K.L. Rao who envisaged construction of Ganga-Cauvery – Canal (ii) Captain Dastur who suggested construction of Garland Canal for Western Ghats watershed to produce power (iii) Sri Paramashivaiah for diverting west flowing rivers. (iv) Diversion of excess of Sharavathi River water to Bangalore. Currently Ettinahole and Mahadai river diversion are being debated for supply of drinking water to Bangalore / Kolar and to Dharwar and Gadag districts respectively.

What is most important is that stake holders should understand the dynamics of surface and Groundwater. As part of the hydrological cycle, certain amount of precipitated rain water flows along the coastal region directly into the sea through porous rocks, fractured hard rocks and sediments. This component designated as Submarine Ground Water Discharge (SGWD) reported by More (1966) in a similar geological terrain, suggests that the contribution by SGWD can be as high as 40% of total water resources. The tracer used in arriving at this quantitative estimation, is Radium (^{226}Ra) and its daughter Radon (^{222}Rn) that are naturally enriched in groundwater. Quantifying the extent of this SGWD loss in the western and the eastern coasts of India has not been attempted so far. The emerging conundrum of conflicts of South Canara-Kolar; Goa-Dharwar are now disturbing and point towards a worrisome future. Since 2012, various authorities in the state have been trying to implement Yettinahole project for Kolar district and Mahadayi project for Dharwar district.

The conflicts are intense, sometimes violent and almost always political between the States and within the states.

8. Karnataka has seven major river systems with a total inflow of 3438 TMC out of which 2000 TMC (58%) is west flowing rivers. Bulk of 1438 TMC runs off rapidly on surface and discharge water with fertile silt into the Arabian Sea. Our concern should be to arrest this flow and allow as much of this excess of water diverted to Eastern drainage to rejuvenate the base flow in Ghataprabha, Malaprabha, Benniballa, Varada, Kumadvathi, Tunga, Bhadra, Vedavati, Yagachi, Hemavathi, Harangi, Laxamanthirtha, Kabini, and Nugu.

Taking these complexities into consideration and large quantity of water that flows to Arabian sea, it is proposed to divert selected small west flowing river waters to increase ground water draft and rejuvenate dry east flowing rivers without affecting Western Ghat environment. Besides Kali, Sharavathi and Netravathi river captures, there are many other small rivers originating in the western ghats, flowed east ward initially and diverted to west subsequently by head ward erosion, ultimately joining the Arabian Sea on the west coast. Major portion of 58% of the life giving water and silt is discharged in to sea without proper utilization.

9. There is a need to calculate the availability of water, length and height of pumping at these points and prepare suitable maps to take forward this proposal. Key catchment map of west-flowing rivers with points to link to the east-flowing rivers is shown in Fig.6. Micro basins catchment areas and selection of points for building suitable check dams for harvesting of rainwater during rainy season on a drainage cadastral map on scale 1:4000 or 1:8000 should be prepared for each micro basin on the eastern drainage with a Digital Elevation Model (DEM). This will enable identification of total rainfall and water resources in a micro basin and management of micro basin aquifers including cropping pattern. There is a need to study in detail the drainage pattern of Western Ghats and select suitable sites for diversion of west flowing micro basin to East so that surplus west flowing water can be diverted to east to rejuvenate dry east flowing tributaries of Godavari, Krishna, Cauvery, Pennar and Palar basins and fill up large empty tanks to charge over exploited groundwater aquifers in dry land areas.

10. **Conclusion :** Study of B.P. Radhakrishna on National Water Summary for India (1992) reports that water is the most abundant and precious among our mineral resources and yet we have not given adequate attention to providing micro basin - wise annual summary of this important resource. He has suggested a planned quantitative appraisal, quite distinct

from “the empirical thumb-rule approach adopted so far” to estimate groundwater potential of major river basins of Karnataka. Some type of a mandatory order is required to persuade all organizations involved to get together and co-operate in the preparation of such a summary based on hard data instead of assumed figures.

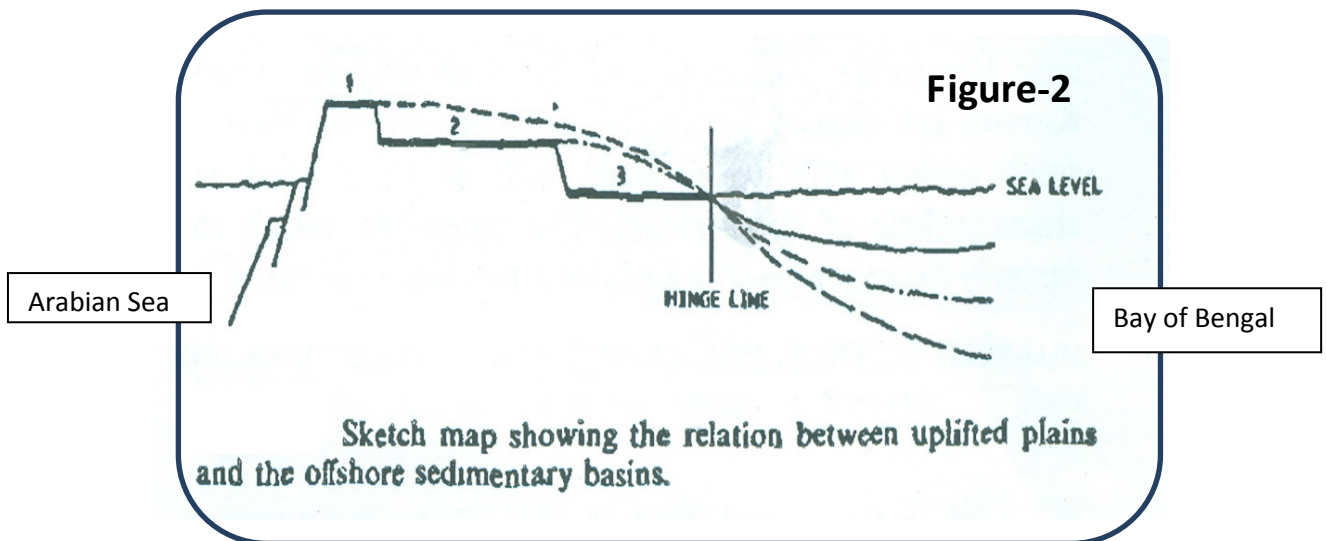
Policy makers ought to find a way out for an equitable distribution of water among all the stake holders. This require a strong political will and states manship of high caliber .Geomorphologists, Geologists, Civil Engineers, Hydrologists, Environment and Agriculture experts and Administrators should sit together and prepare a plan of preeasibility with financial implication . This should include methods to charge the depleting groundwater to rejuvenate Macro and Micro rivers to meet the demands of drought - prone areas in Peninsular India.

References:

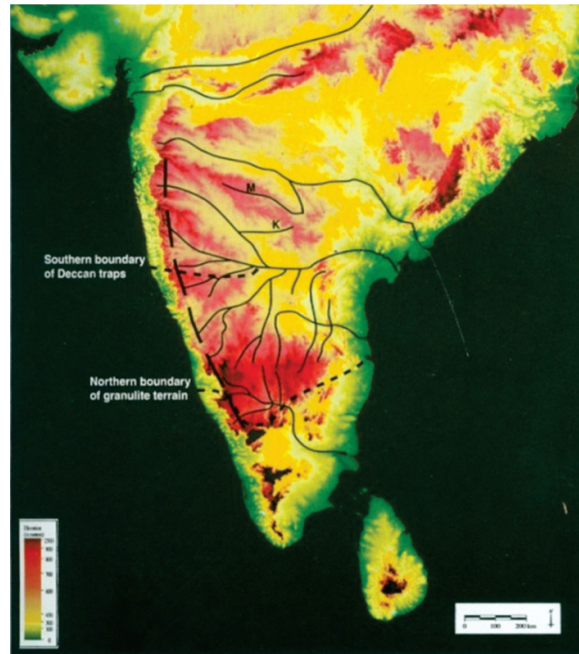
1. GUNNEL, Y. AND RADHAKRISHNA, B.P. (2001) Sahyadri: The Great Escarpment of the Indian subcontinent GSI-Memoir- 47, Vol. 1 & 2, ISBN: 81-82867-45-3 & 43-1.
2. MORE, W.S.S April (1966) Submarine Groundwater Discharge Nature Vol. 380, NO. 6575, pp. 612-614
3. PARAMASHIVAIAH (2013) Diversion of 11 Sea Flowing Rivers to meet the seven district. Report submitted Government of Karnataka.
4. RADHAKRISHNA B.P., (1952) Mysore Plateau, its structural and physiographic evolution Bull Mysore Geologists Association No. 3.
5. SAWKAR R.H. (2013). Evaluation of Surface, ground and sewage water for sustainable supply of potable water to Bangalore, Jour. Geol. Soc. India, Vol.80, Dec. 2012.
6. SAWKAR, R.H. (2012) Groundwater Development and Rainwater Harvesting in Greater Bengaluru, Geological Society of India, ISBN No. 978-93-80998-00-8
7. Sawkar R.H. (2016) Sustainable Water Resources of Sahyadri: the Great Escarpment of the Indian Subcontinent JGSI Vol. 87, No. 4, pg. 377-382
8. State Environmental Report 2003 and 2007
9. SUBRAMANYAN, K.R. (1994) Post Gondwana Tectonics of the Indian Peninsula current Science V. 67, pp. 527-530
10. VAIDYANADHAN (1977) Recent Advances in Geomorphic Studies in Peninsular India a review. Indian Journal of Earth Sciences Ray Volume pp.13-35
11. VAIDYANADHAN, R and SubbaRao, K.V. (2014) Geological Society of India (ISBN978-93-80998-02-2)
12. VALDIA, K.S. (2001) River response to continuing movements and ScrapDdevelopment in Central Sahyadri and adjoining coastal belt JGSI Vol. 57, pp. 13-20.
13. Vaidyanadhan, A (2013) Water Resources of India Oxford University Press of India 11p.



Fig.1 The northward drift of India from 71 million years ago to present time. Note this simultaneous counter clockwise rotation of India. Collision of Indian continent with Eurasia occurred at about 55 million years ago (Credit: Wikipedia sourced from www.usgs.org)



Himalaya was only considered as mountain building activity. B.P. Radhakrishna proposed periodic upliftment of Deccan Plateau resulting in Nilagiri, Sahyadri, Sivanasamudram hill ranges.



Hypsometry, in metres, of Peninsular India after reclassification of a GTOPO30 Digital Elevation Model. An overlay showing the principal drainage arteries reveals that river systems do not simply and straight forwardly follow the general slope of the subcontinent from west to east, but rather flow SW-NE in Karnataka, and NESW in Maharashtra. A few rivers flowing westward (marked K: Kagna) or exhibiting a sharp boat-hook bend (marked M: Manjra) in the Deccan Trap region additionally indicate a complex Cenozoic drainage history. (*source*: Gunnell and Radhakrishna, 2001)



Extent of the vast plan lands (erosion surfaces) of the Indian Peninsula is demarcated by clear-cut Scarps. Solid Black: oldest erosional remnants (Gondwana surface); stippled; post Cretaceous second younger surface; Unstippled; the youngest erosional surface (Tertiary-Recent)

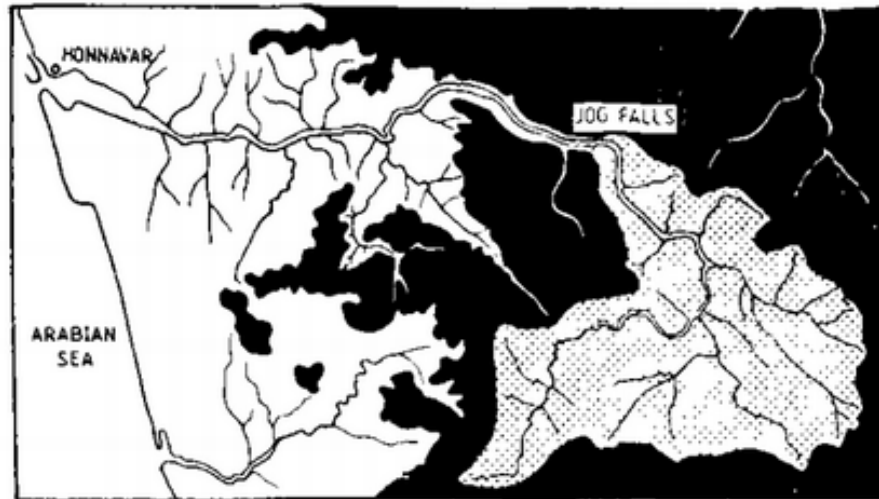


Fig.4 River capture along with Western Ghat. The West flowing Kali and Gangavali rivers have captured the easterly drainage above the Ghat.



Fig.5 The Sharavathi River, A west-flowing consequent stream, capturing the easterly drainage above the Ghat. The recession of the waterfall (Jog Falls), and carving out of a 20 km long gorge points to its recent origin

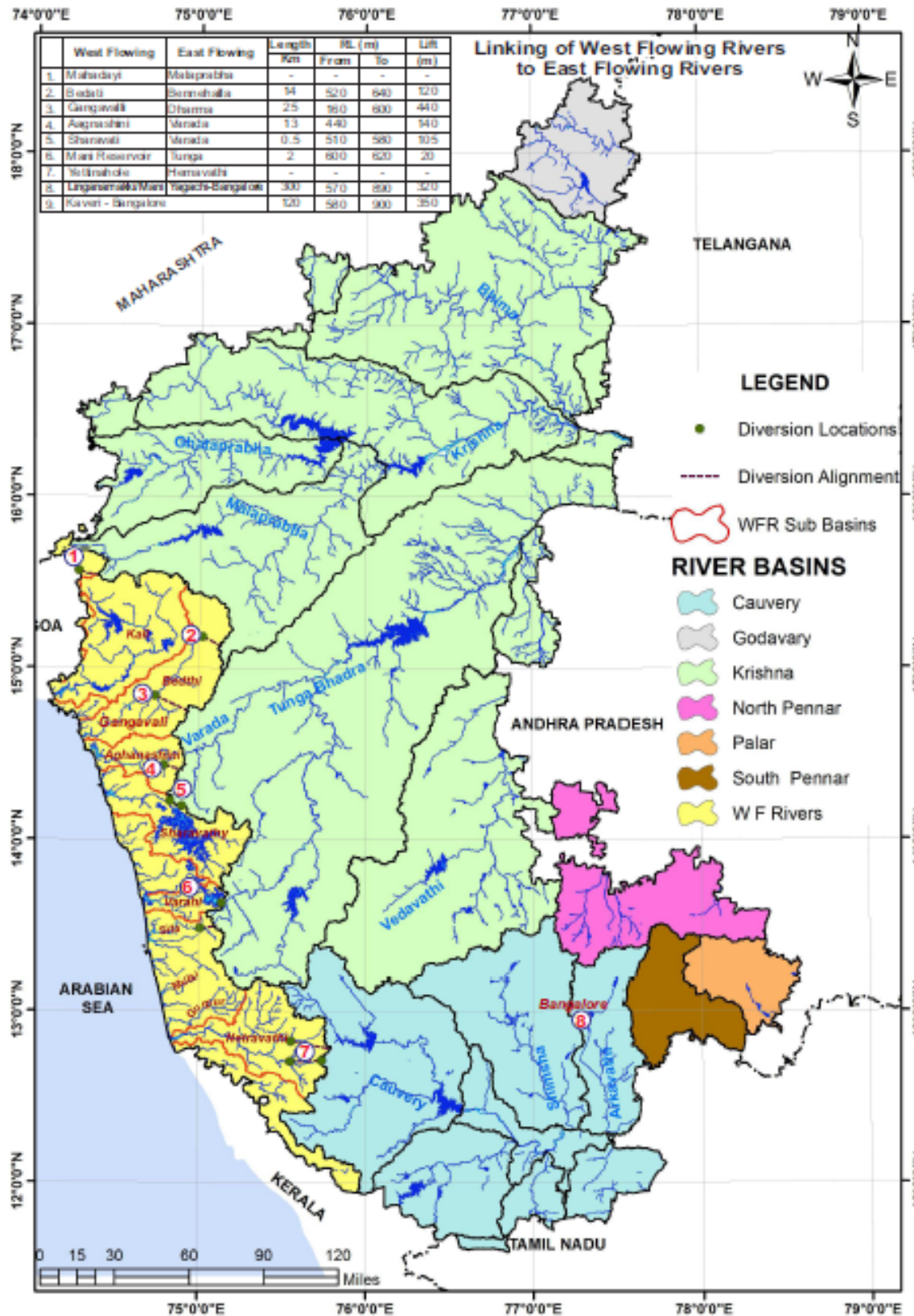


Fig.6 West flowing river basin map showing the linking points to east flowing rivers

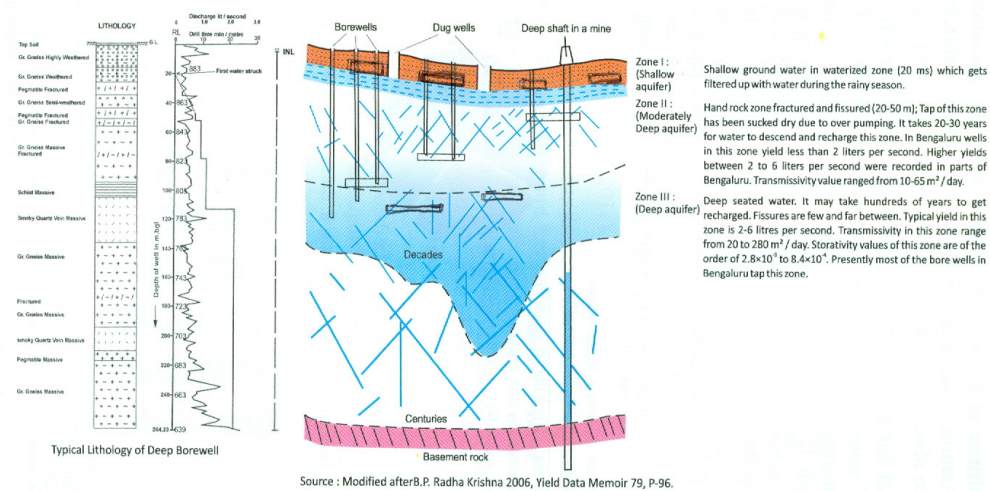


Fig. 7 Schematic Cross Section showing zones of Water accumulation in hard rock

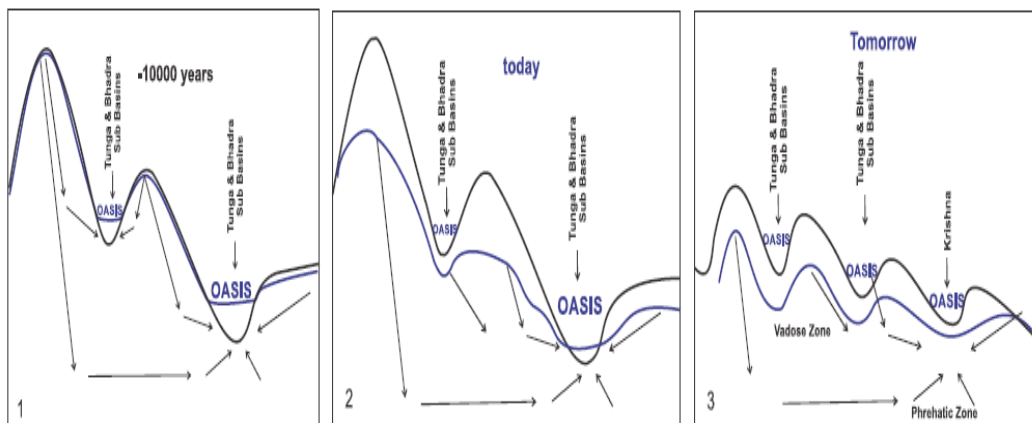


Fig. 8 Zones of water accumulation in hard rock areas – Depression of Groundwater table

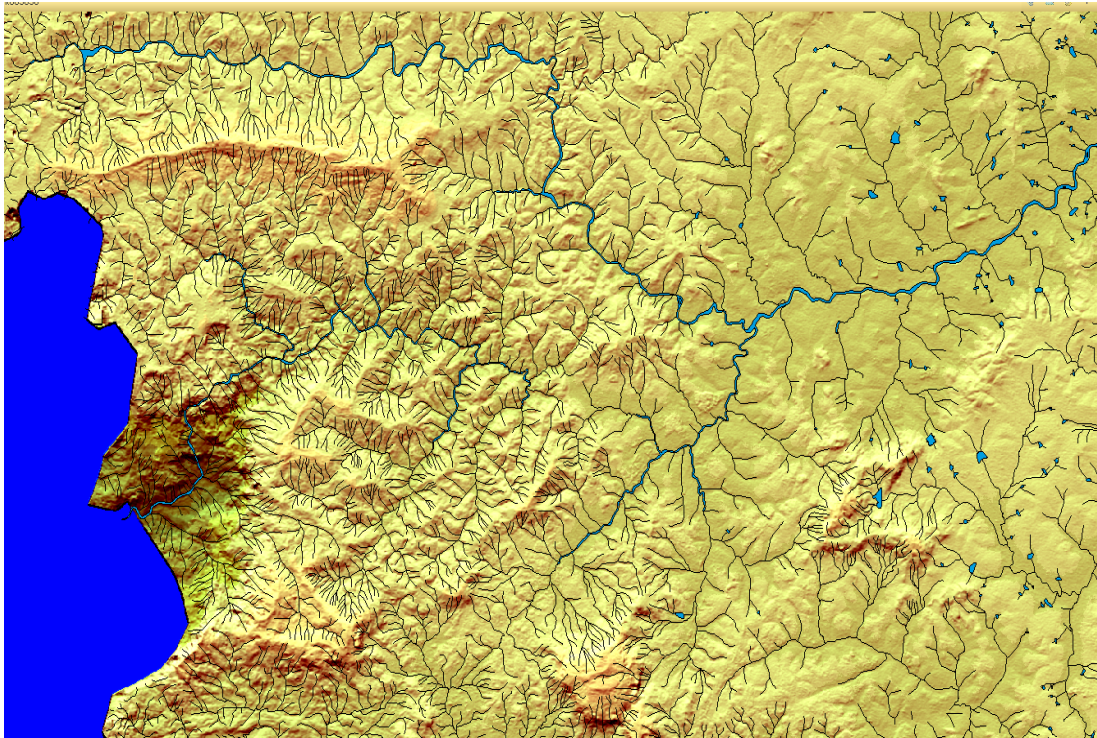


Fig. 9 Mahadai River

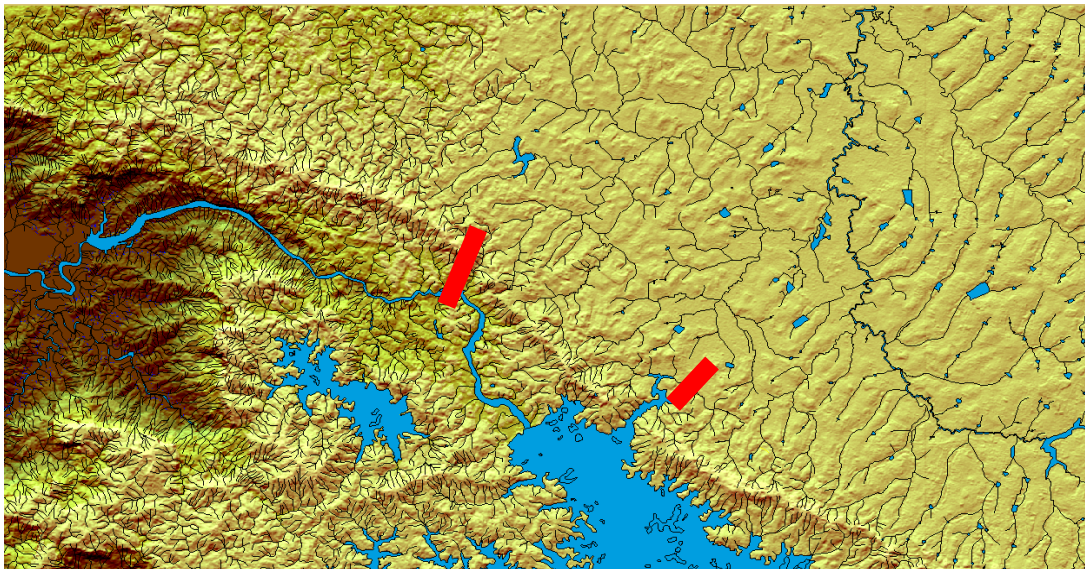


Fig. 10 Sharavathi River

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