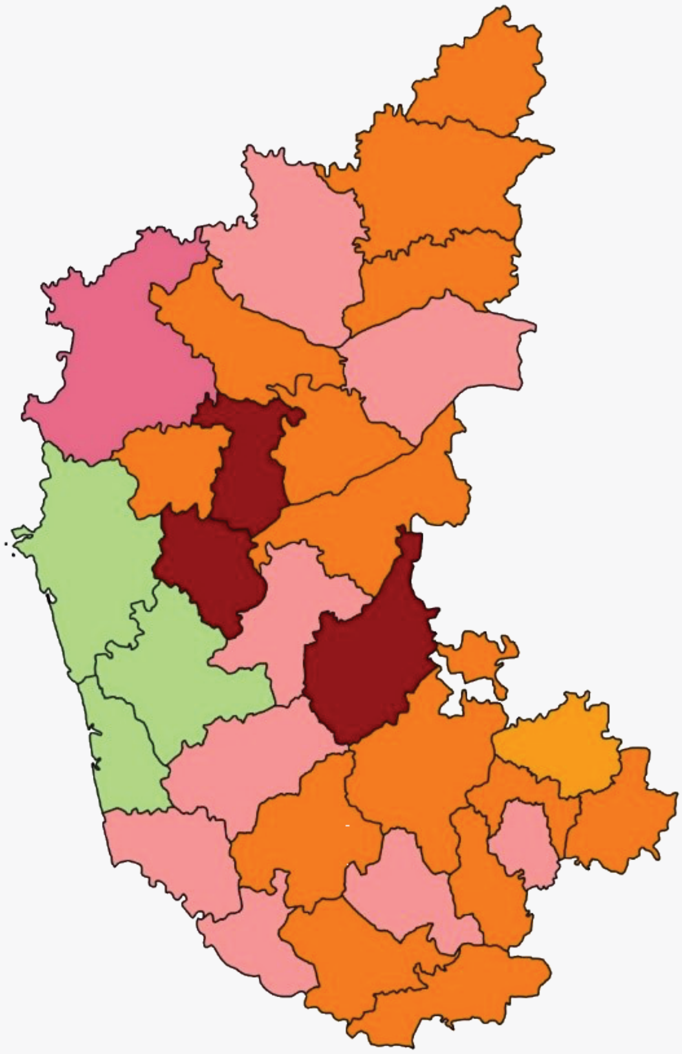
Promising Climate Resilient Technologies for Karnataka



National Innovations in Climate Resilient Agriculture

ICAR-Central Research Institute for Dryland Agriculture, Hyderabad
Agricultural Technology Application Research Institute, Bengaluru
Natural Resource Management & Agricultural Extension Divisions
Indian Council of Agricultural Research (ICAR), New Delhi

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VK Singh, JVNS Prasad, DBV Ramana, K Nagasree, R Rejani, G Venkatesh, DVS Reddy, V Venkatasubramanian, M Prabhakar, S Bhaskar, SK Chaudhari, AK Singh

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Citation:

Singh, V.K., Prasad, J.V.N.S., Ramana, D.B.V., Nagasree, K., Rejani, R., Venkatesh, G., Reddy, D.V.S., Venkatasubramanian, V., Prabhakar, M., Bhaskar, S., Chaudhari, S.K. and Singh, A.K. 2021. Promising Climate Resilient Technologies for Karnataka. ICAR-Central Research Institute for Dryland Agriculture, Hyderabad. 87p

Copies : 100

September, 2021

Facilitated by

Agricultural Technology Application Research Institute (ATARI) - Bengaluru

KVKs – ATARI Bengaluru

Editorial assistance (Research Associates/fellow)

ICAR-CRIDA: C.M. Pradeep, B.V.S. Kiran, Kalyana Srinivas, S. Raghava Sharma, K. Elisha

ISBN: 978-93-80883-59-5

Published by

The Director
ICAR-Central Research Institute for Dryland Agriculture
Santoshnagar, Hyderabad-500059. Ph: 040-24530177 Fax: 040-24531802
E-mail: director.crida@icar.gov.in

Front Cover : Risk prone districts and interventions of NICRA in the state of Karnataka

Back Cover : 151 districts involved in NICRA and their climatic vulnerabilities

Printed at:

Balaji Scan Pvt. Ltd.,
Nampally, Hyderabad-500 001
Tel: 9248007736/37
E-mail: bsplpress@gmail.com Website: www.balajiscan.com

सत्यमेव जयते
त्रिलोचन महापात्र, पीएच.डी.
सचिव, एवं महानिदेशक
TRILOCHAN MOHAPATRA, Ph.D.
SECRETARY & DIRECTOR GENERAL

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि एवं किसान कल्याण मंत्रालय, कृषि भवन, नई दिल्ली 110 001

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Foreword

Climate change is impacting agriculture in developing world and affecting livelihood of people in the region. Indian Council of Agricultural Research (ICAR) has initiated a comprehensive programme, namely National Innovations in Climate Resilient Agriculture (NICRA) to address various aspects of climate change. The Technology Demonstration Component of NICRA is demonstrating location specific proven technologies, developed by NARS, to farmers in a participatory manner in 446 villages of the country representing 151 climatically vulnerable districts. This is enhancing adapting capacity and resilience of farmers, and can be propagated in other parts of the country.

Necessary institutional support is being provided by way of setting up custom hiring centers, seed and fodder production systems for enhancing the spread and adoption of technologies in these villages. In the State of Karnataka, six districts are involved in the program focusing on drought. Proven technologies, which can minimize the impact of drought during the stress years and enhance production and profitability during the normal years, were identified based on the on-farm demonstrations conducted during the last ten years. This publication documents about 60 such technologies, which can be further upscaled in similar farming situations and resource endowments. Mainstreaming of these promising resilient practices to the ongoing development programmes is imperative so as to reach large number of farmers to further minimize the impacts of climatic variability.

I compliment the authors in bringing out the publication for the State of Karnataka, and acknowledge the cooperation of participating farmers in NICRA villages. I hope, this publication will be of immense value to all the stakeholders engaged in implementation and spread of climate resilient technologies.

(T. MOHAPATRA)

Dated the 9th September, 2021
New Delhi

PREFACE

Climate change and variability is having profound effect on food production systems. Karnataka is one of the frequently drought prone state in India. Consistent warming trends and more frequent extreme weather events such as droughts, cyclones and hailstorms have been observed across the state in recent decades. The Technology Demonstration Component of National Innovations in Climate Resilient Agriculture (NICRA) specifically aims at identifying climate resilient technologies in partnership with the farming community to cope up the climatic variability and enhance their adaptive capacity contributing to resilience. Participatory on-farm demonstrations were taken up in six districts of the state during the last ten years for addressing various climatic vulnerabilities in Karnataka. Promising resilient technologies pertaining to natural resource management, crops and cropping systems and animal and fisheries related were demonstrated with participation of farmers. The impact of these practices during the normal and stress years and resilience was assessed and documented in this book. Village institutions such as VCRMC, seed and fodder production systems, CHC are being established to strengthen and spread of resilient practices in the villages. The proven resilient practices were scaled up in convergence with various ongoing developmental programmes.

The technologies adopted by farmers could minimize the impact of weather aberrations and contribute towards sustainability and built resilience. Technologies which were found to be promising are documented and evidences along with the economics during the stress year are presented. Compiling the promising technologies in the form of publication serves as guide for all the stakeholders for scaling climate resilient technologies as part of various developmental programmes operational in the state. The upscaling areas for each of the technology was discussed and the possible development programs which can be leveraged for upscaling the technologies is given in the publication. Besides, the promising resilient technologies can be integrated into the State Climate Change Action Plans so as to mobilize additional resources for scaling these technologies.

We take this opportunity to gratefully acknowledge the constant guidance and support from Dr. Trilochan Mohapatra, Secretary (DARE) & Director General (ICAR), members of the High-Level Monitoring Committee, Zonal Monitoring Committee Chairmen and members, Directors of Extension of the State Agricultural and Veterinary Universities, officials of Development Departments and KVKs of the state. We gratefully acknowledge the valuable contribution of farmers, VCRMC members and other stakeholders of the project.

Authors

CONTENTS

LIST OF ACRONYMS

ATMA	Agricultural Technology Management Agency
BCCIK	Bangalore Climate Change Initiative Karnataka
CFLDs	Cluster Frontline Demonstrations
CGWB	Central Ground Water Board
CHC	Custom Hiring Centers
FPO	Farmer Producer Organizations
INCCA	Indian Network for Climate Change Assessment
IWMP	Integrated Watershed Management Programme
KMF	Karnataka Milk Federation
KVK	Krishi Vigyan Kendra
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
NABARD	National Bank for Agriculture and Rural Development
NDDB	National Dairy Development Board
NFSM	National Food Security Mission
NHM	National Horticulture Mission
NGO	Non-Government Organizations
NICRA	National Innovations in Climate Resilient Agriculture
PMKSY	Pradhan Mantri Krishi Sinchayee Yojana
SAUs	State Agricultural Universities
TDC	Technology Demonstration Component
VCRMC	Village Climate Risk Management Committee

1. Introduction

1. Introduction

Karnataka is located between 11°30' to 18°30' N latitude and 74° 00' to 78°30' E longitude. The state is surrounded by Maharashtra to the north, Goa to the northwest, Arabian sea to the west, Kerala to the south, Tamil Nadu to the southeast, Andhra Pradesh to the east and Telangana to the north east (Fig. 1.1). The state has three principal geographical zones, including coastal zone (Karavali), Western Ghats (Malenadu), Deccan Plateau (Bayalu Seeme) and it is divided into 10 agro-climatic zones considering the extent and distribution rainfall, soil characteristics, elevation, topography, major crops and vegetation. Karnataka extends about 750 km from North to South, about 400 km from East to West with a coastline of 310 km. The highest point in Karnataka is the Mullayanagiri hill in Chickamagaluru district which has an altitude of 1929 metres above mean sea level (MSL). The total area of the state is about 191 lakh ha, which covers about 5.83% of the total area of the country and land use pattern of the state is shown in Fig. 1.2.

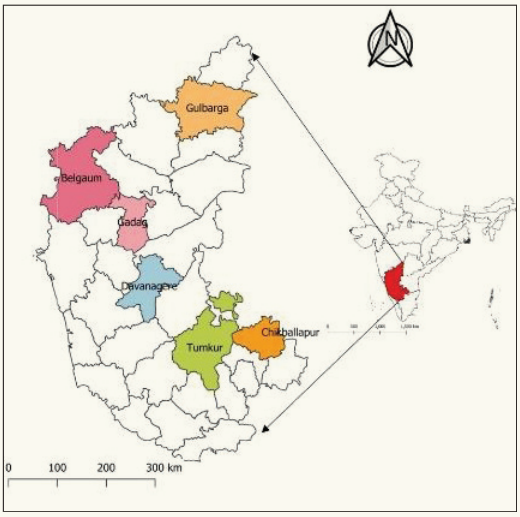


Fig. 1.1 Location map of Karnataka

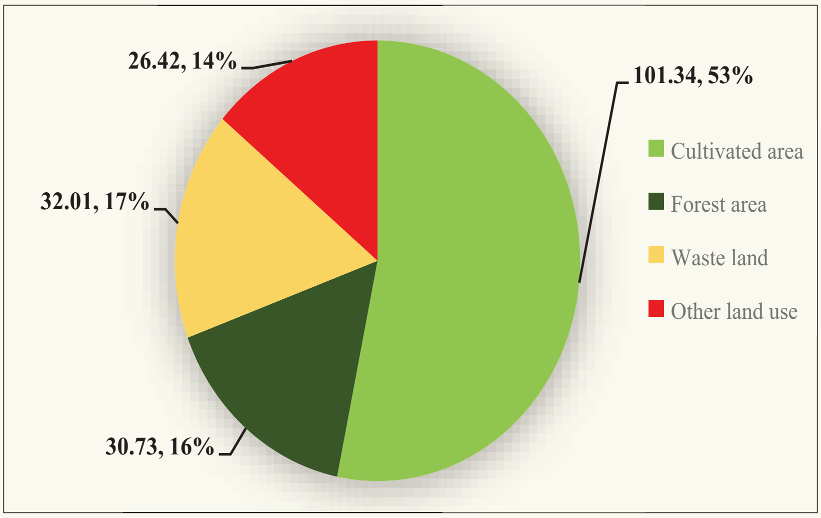


Fig. 1.2 Land use pattern of Karnataka

Climate: Karnataka has tropical monsoon climate with hot, moist cool and dry winters. The state experiences winter in January and February, summer during March to May, south-west monsoon from June to September and north-east monsoon from October to December. The state is divided into four meteorological zones *viz.,* Coastal, Malnad, North interior and South interior. The southwest monsoon accounts for almost 75 % of the total rainfall. The normal rainfall across the state ranges from 477 mm (North interior) to as high as 4747 mm (Coastal area). The state experiences lowest temperature during the month of January and the temperature begins to rise rapidly during March. The southern part of the state generally experiences the highest temperature during the month of April and coastal plains during the month of May. The temperature starts decreasing during month of October and comes down further during December. The average maximum temperature during summer is 34˚C across the state and the average day temperature during monsoon is 29˚C. During winter, mean temperatures ranges from 32˚C to below 20˚C.

Soil: Eleven groups of soil are found in the state and depending on the agricultural capability, the soils are classified into six types viz., red soils (red gravelly loam, red loam, red gravelly clay and red clay), black soils (deep, medium and shallow black soils), lateritic soils (lateritic gravelly and lateritic), alluvial soils (non-saline, saline and sodic), forest soils (brown forest soils) and coastal soils (coastal laterite and coastal alluvial).

Cropping pattern: The state has net sown area of 101.34 lakh ha, out of which irrigated area is 29.1 (28%) lakh ha and remaining area of 72.24 (72%) lakh ha under rainfed condition. Percentage area under irrigation is highest in crops like sugarcane (is about 85.3%), followed by cereals (32.5%), fibre crops (28.3%, mainly cotton), oil seeds (20.8%) and pulses (5.8%). During *kharif* season, 33.4% (23.2 lakh ha) area is covered under coarse cereals (jowar, maize, finger millet, pearl millet etc.,) followed by pulses in 17.5% (12.2 lakh ha), cereals in 14.4 % (10.0 lakh ha), oilseeds in 14.3% (9.9 lakh ha), fibre crops in 11.4% (7.9 lakh ha) and other crops in 8.9 % area (6.2 lakh ha). During *rabi* season, 41% (12.0 lakh ha) is covered with pulses, followed by coarse cereals in 37.1% (10.9 lakh ha, mainly jowar), oilseeds in 9.9% (2.92 lakh ha), cereals in 7.7% (2.3 lakh ha), fibre crops in 2.4 % (0.71 lakh ha) and other crops in 1.7 % area (0.51 lakh ha).

1.1 Climate change in Karnataka

The analysis of mean rainfall variation at state level, regional and district level showed both positive (increase) and negative (decrease) shifts. The observed positive change in rainfall (mm) at district level varied from 4 mm (Belagavi district) to 119 mm (Shivamogga district), whereas the negative shift ranged from -314 (Dakshina Kannada) to -7 mm (Bengaluru Rural district). An increase in mean rainfall was observed in Shivamogga, Hassan, Kolar, Mysuru, Chitradruga and Bengaluru Urban districts. A decrease in mean rainfall was observed in Kalaburagi, Yadgir, Bagalakote, Vijayapura and Dakshina Kannada districts and an increase in mean rainfall was observed in Shivamogga and Hassan districts.

The temperature and relative humidity data from 2002 to 2018 was analysed and the average annual temperatures showed an increasing trend in Bengaluru Urban, Bengaluru rural, Ramanagara, Kolar, Chikkaballapur, Tumkuru, Mandya districts of South Interior Karnataka (SIK) region, Ballari district of North Interior Karnataka (NIK) region, Dakshina Kannada of Coastal region. The average relative humidity showed significant decreasing trend in Chitradurga, Davangere, Mysuru, Mandya districts from SIK region, Ballari, Koppala, Belagavi, Haveri, Gadag, Dharwad from NIK region, Shivamogga, Hassan, Kodagu from Malnad region and Uttara Kannada district from Coastal region. Among the regions, Malnad and Coastal regions showed a significant decreasing trend (KSNDMC 2020).

Karnataka has experienced several extreme weather events in the last decades. Consequently, the state has frequently confronted with various hydro-meteorological disasters such as drought, flood, hailstorm, cyclone, landslides, heat waves etc, which has caused enormous damage to life, property, crops and critical infrastructure. Drought is the most common and recurring hydro-meteorological disasters in the state. Karnataka is the most drought-prone state after Rajasthan in India. Nearly 80% of Taluks in the state are drought-prone. In the last two decades (2001-2019), the state has experienced drought of varying severity and 2005, 2010 and 2017 were exceptions. According to the Ministry of Agriculture and Farmers Welfare (MoAFC&W), Government of India (GoI), 16 districts of the state, mainly from NIK, experienced 10 drought years during last 15 years (2001–2015). The drought causes crop loss, drinking water scarcity, fodder scarcity, loss of livelihood, unemployment to rural agricultural laborers, large scale migration etc. Increased incidence of droughts reduces crop productivity, affecting nutrition and consequently, resistance to infections. Floods have been a devastating hydro-meteorological natural disaster recurring both in riverine areas and urban areas of Karnataka. Karnataka experienced severe floods during 2005, 2009, 2018 and 2019. As a result of the severe depression in Bay-of-Bengal, the state experienced catastrophic floods in the districts of North Interior Karnataka in October 2009, which caused immense damage to livelihood, property and critical infrastructure in 7 districts of the region (KSNDMC 2020).

Hail storms are also among the major disasters over the State in recent years. During pre-monsoon (March to May), the frequency of hail storms associated with thunder storm activity and gusty winds with intensified rainfall is damaging the infrastructure, crops, human lives and livestock. Loss is mainly over Northern part of the State every year since 2014. North Interior Karnataka being a part of semi-arid region is continuously experiencing hailstorm events in majority of the areas. During pre-monsoon period of 2015, the hailstorm accompanied with high intensity rainfall and gusty winds with thunderstorm activity occurred in 8 districts of North Interior Karnataka *viz.,* Bidar, Kalaburgi, Yadgir, Bellary, Raichur, Koppal, Vijayapura and Gadag. The paddy grown in Tungabhadra reservoir command area and Narayanapur reservoir command area were almost in harvesting stage and the horticulture crops like mango, grapes, pomegranate, sapota etc., were subjected to heavy hailstorm associated with high velocity wind. Consequently, the State suffered an unprecedented hailstorm related loss to the tune of Rs. 422.36 Crores (KSNDMC 2020).

The Karnataka state has about 320 km of coastline, in the western part bordering the Arabian Sea. Though historically, Karnataka State was not experiencing any major cyclone event but in the last decade, frequency of cyclonic storm in the Arabian has increased and the cyclone risk has increased in the coastal and adjoining areas of the state. There were about 16 cyclonic storms developed in the Arabian Sea in the last 10 years, in which 5 of them were in 2019 and one in 2020. The human population, critical infrastructure and private properties all along the 320 km coastline and the adjoining areas are highly vulnerable to cyclone risk (KSNDMC 2020). As large parts of Karnataka are under arid to semi-arid condition, the state is experiencing the heat-wave like condition in the recent years. Karnataka has been experiencing higher than normal temperatures particularly in districts belonging to North Interior Karnataka and these districts are prone to high temperature for a longer duration in a year. Coastal and South Interior Karnataka are less prone to heat wave as compared to NIK.

1.2 Challenges of Karnataka agriculture in the context of climate change

Agriculture is the most vulnerable sector to climate change due to its high dependence on climate and weather and people involved in agriculture are less resourceful compared to urban residents. More than 60% of the state population is directly or indirectly dependent on agriculture. Consistent warming trends and more frequent and intense extreme weather events such as droughts, cyclones and hailstorms have been observed across the state in recent decades. Karnataka is expected to be one of the most vulnerable states to climate change. The coastal areas too are believed to be susceptible. Rainfall and temperature in the state are highly variable. The crops are generally rainfed in nature, and therefore have been at the risk of the vagaries of weather.

Bangalore Climate Change Initiative Karnataka (BCCIK) model projected that north-east and south-west parts of the state may experience decrease in the overall rainfall and reduction of precipitation during June, July, August and September months in all districts of Karnataka except Bidar, Chikmagalur, Haveri, Kodagu, Shimoga, Udupi and Uttara Kannada. BCCI-K's study projects a further warming of 1.8 to 2.2 °C by

2030. The projected increase for annual temperature for the northern districts is higher than the southern districts. Projected minimum temperature increases are slightly above increase in the maximum temperatures.

Productivity of irrigated rice may change by -14.4 to 9.5% from its base yield and major part of the irrigated rice cultivating area is projected to experience a reduction of yield up to 8.2% while smaller non-rice growing districts are projected to record up to 6.2% higher yields. The yield of rainfed rice may change between -13.8 to 7.2 % with large region losing up to 9.6%. Maize and sorghum yield have been projected to change from 27.6 to -19.3% and 17.2 to -18.4% respectively from its baseline yield (KSAPCC - 2013).

Indian Network for Climate Change Assessment (INCCA) reported that 2.1 °C rise in mean temperature and 4.5% increase of mean rainfall would reduce net productivity in the state by 1.2%. The state may record 12.3% less food production due to climate change but enhanced CO_2 and rise in temperature may also cause significantly higher productivity up to 35% in few districts by 2030 (KSAPCC - 2013).

1.3 Overview of the agro-ecosystems and predominant production systems in the selected districts under NICRA

Karnataka state is divided into 10 agro-climatic zones considering the extent and distribution rainfall, soil characters, elevation, topography, major crops and vegetation. North Eastern Transition zone (Zone I): The rainfall in the region varies from 830 to 890 mm and soils are shallow to medium black. The important crops grown in the region are pulses, jowar, oilseeds, bajra, cotton and sugarcane. North Eastern dry Zone (Zone II): the annual rainfall varies from 633 to 806 mm and the principal crops grown are bajra, pulses, cotton, oilseeds and *rabi* jowar. Northern Dry Zone (Zone III): The normal annual rainfall of the zone ranges from 464 to 785 mm and maize, bajra, groundnut, cotton, sugarcane, rabi jowar, wheat and tobacco are the important crops in the region. Central Dry Zone (Zone IV): The annual rainfall ranges from 453 to 717 mm and major crops grown in the region are finger millet, jowar, pulses and oilseeds. Eastern Dry Zone (Zone V): The annual rainfall of the zone ranges from 679 to 888 mm and finger millet, rice, pulses, maize and oilseeds are the major crops in the region. Southern Dry Zone (Zone VI): The zone receives annual rainfall from 670 to 889 mm and principal crops grown are rice, finger millet, pulses, jowar and tobacco. Southern Transition Zone (Zone VII): This zone receives annual rainfall in the range of 612 to 1054 mm and the important crops grown are rice, finger millet, pulses, jowar and tobacco. Northern Transition Zone (Zone VIII): The annual rainfall in the zone varies from 619 to 1303 mm and main crops grown in the zone are rice, jowar, groundnut, pulses, sugarcane and tobacco. Hilly Zone (Zone IX): This zone receives annual rainfall in the range of 904 to 3695 mm and principal crops are rice and pulses. Coastal Zone (Zone X): The annual rainfall ranges from 3011 to 4694 mm and crops grown are rice, pulses and sugarcane. The districts involved in TDC-NICRA programme are discussed below.

1.3.1 Kalaburagi

Kalaburagi district lies in the northern part of Karnataka between 16°42′ to 17°46′ N latitude and 76°04′ to 77°41′ E longitude with an altitude of 444 m above MSL (Fig. 1.3). The district falls under semi-arid Deccan plateau, hot arid eco-subregion (3.0) of agro-ecological sub region, Southern plateau and hill region (X) of agro-climatic region and North Eastern Dry Zone (KA-2), North Eastern transition zone (KA-1) and North Dry Zone (KA-3) of agro-climatic zone. The geographical area of the district is 16.10 lakh ha, out of which, cultivable area is 8.42 lakh ha, forest area is 0.69 lakh ha and the other land use pattern of the district is shown in Fig. 1.4. Crops are grown in the district under rainfed situation is 9.74 lakh ha and net irrigated area is about 1.83 lakh ha. The source of irrigation in the district are canals, tanks, open wells, bore wells, lift irrigation schemes and other sources. The normal average annual rainfall of the district is 842 mm and seasonal rainfall is shown in Fig. 1.5. The district is predominantly covered with deep black clayey soil, shallow mixed black clayey and loamy soil, deep alluvial black calcareous clayey soil and very shallow alluvial loamy soil (Fig. 1.6). Crops grown during *kharif* and *rabi* season are shown in Table 1.1. The district receives low rainfall with high risk category and drought proneness may likely to increase.

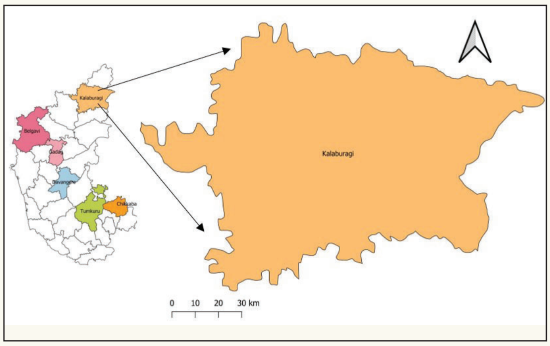


Fig. 1.3 Kalaburagi district

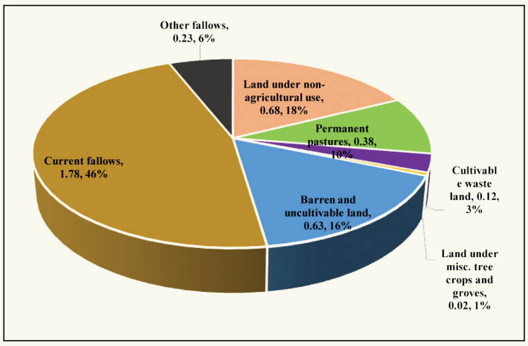


Fig. 1.4 Land use pattern (Area in lakh ha)

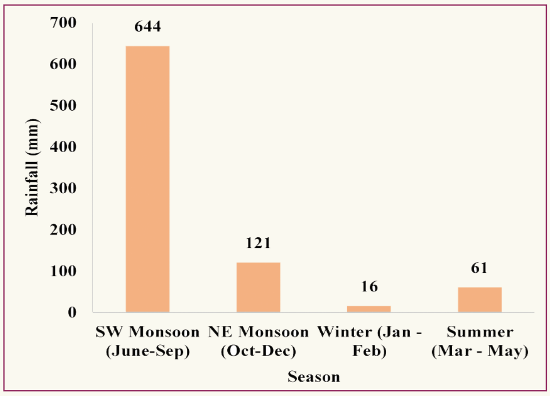


Fig. 1.5 Season wise rainfall (mm)

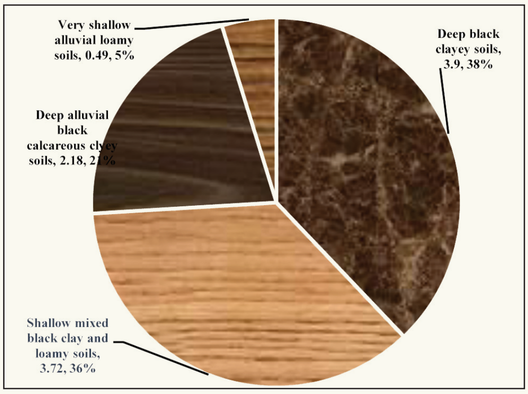


Fig. 1.6 Major soil classification (Area in lakh ha)

Table 1.1 Area wise and crop wise irrigation status at Kalaburagi district

Crop type	Kharif (ha)			Rabi (ha)			Summer (ha)			Total		
	IRR	Rainfed	Total	IRR	Rainfed	Total	IRR	Rainfed	Total	IRR	Rainfed	Total
Cereal	2374	0	2374	10185	1160	11345	3568	0	3568	16127	1160	17287
Coarse cereal	507	17674	18181	2872	200248	203120	519	0	519	3898	217922	221820
Pulses	1366	416447	417813	5355	191260	196615	440	0	440	7161	607707	614868
Oil seeds	1088	37848	38936	4531	38805	43336	3528	0	3528	9147	76653	85800
Fibre	0	0	0	0	0	0	0	0	0	0	0	0
Horticulture plantation	20835	0	20835	0	0	0	0	0	0	20835	0	20835
Any other crops	56285	40912	97197	0	0	0	26082	0	26082	82367	40912	123279
Total	**82455**	**512881**	**595336**	**22943**	**431473**	**454416**	**34137**	**0**	**34137**	**139535**	**944354**	**1083889**

(IRR - Irrigated)

1.3.2 Gadag

Gadag district situated between 15°15′ to 15°45′ N latitude and 75°20′ 75°47′ E longitude with altitude of 655.3 m above mean see level (Fig. 1.7). The district falls under Deccan Plateau, hot semiarid eco-subregion (6.1) of agro-ecological sub region, Southern Plateau and Hill Region (X) of agro-climatic region and Northern Dry Zone (KA- 3) of agro-climatic zone. The geographical area of the district is 4.657 lakh ha, out of which, cultivable area is 3.801 lakh ha, forest area is 0.32 lakh ha and the other land use pattern of the district is shown in Fig. 1.8. Crops grown in the district under rainfed situation is 3.12 lakh ha and net irrigated area is about 0.695 lakh ha. The source of irrigation in the district are canals, tanks, open wells, bore wells, lift irrigation schemes and other sources. The normal average annual rainfall of the district is 630.3 mm and seasonal rainfall is shown in Fig. 1.9. The district is predominantly covered with medium black soils, deep black soils, shallow black soils red and black mixed soil and red sandy soils (Fig. 1.10). Crops grown during *kharif* and *rabi* season in the district are as shown in Table 1.2. The district receives low rainfall and is under high-risk category. The district may likely to experience increase in drought proneness as a future hazard and it may also experience rise in minimum temperature.

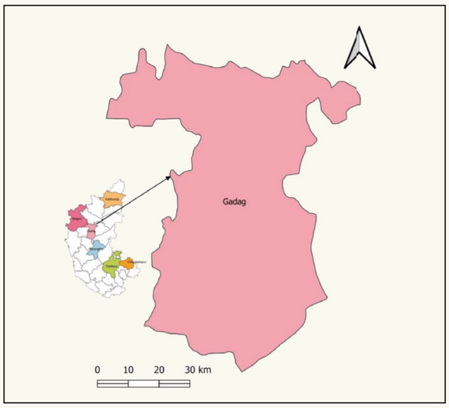


Fig. 1.7 Gadag district

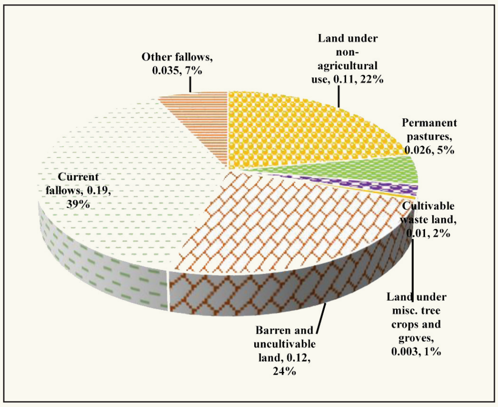


Fig. 1.8 Land use pattern (Area in lakh ha)

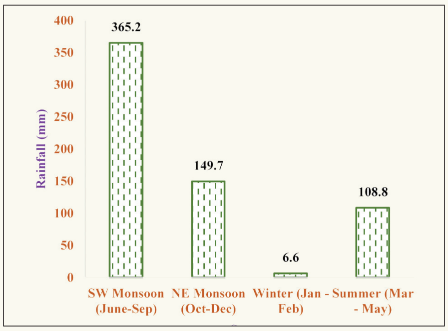


Fig. 1.9 Season wise rainfall (mm)

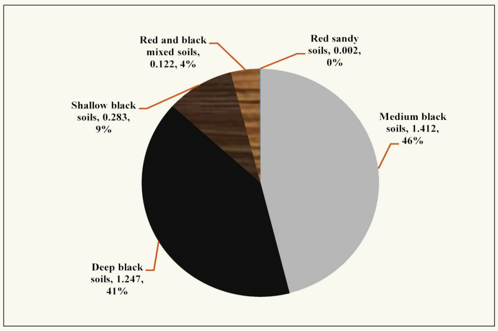


Fig. 1.10 Major soil classification (Area in lakh ha)

Table 1.2. Area wise and crop wise irrigation status at Gadag district

Crop type	Kharif (ha)			Rabi (ha)			Summer (ha)			Total		
	IRR	Rain-fed	Total	IRR	Rain-fed	Total	IRR	Rain-fed	Total	IRR	Rain-fed	Total
Cereal	1000	0	1000	0	0	0	1100	0	1100	2100	0	2100
Coarse cereal	30000	10508	40508	16261	81039	97300	200	0	200	21500	116508	138008
Pulses	0	74500	74500	19350	58350	77700	300	0	300	6500	146000	152500
Oil seeds	18500	25250	43750	10200	21300	31500	13200	0	13200	21200	67250	88450
Fibre	24250	19250	43500	5500	44500	50000	0	0	0	9600	83900	93500
Horticulture plantation	42604	15034	57638	0	0	0	0	0	0	42604	15034	57638
Any other crops	2700	0	2700	2200	0	2200	1600	0	1600	6500	0	6500
Total	**119054**	**144542**	**263596**	**53511**	**205189**	**258700**	**16400**	**0**	**16400**	**110004**	**428692**	**538696**

(IRR - Irrigated)

1.3.3 Tumkuru

Tumkuru district is located in the south eastern part of Karnataka and it lies between 12°45′ to 14°22′ N latitude and 76°24′ to 77°30′ E longitude with an altitude of 894.6 m above MSL (Fig. 1.11). The district falls under Central Karnataka plateau, hot, moist, semi-arid eco-subregion (8.2) of agro-ecological sub region, Southern Plateau and Hills Region (X) of agro-climatic region and Central Dry Zone (KA-4) of agro-climatic zone. The geographical area of the district is 10.65 lakh ha, out of which, cultivable area is 5.83 lakh ha, forest area is 0.45 lakh ha and the other land use pattern of the district is shown in Fig. 1.12. The crops grown in the district under rainfed situation in 4.65 lakh ha and net irrigated area is about 1.18 lakh ha. The source of irrigation in the district are bore wells (1.21 lakh ha), tanks (0.02 lakh ha), open wells (0.01 lakh ha) and lift irrigation schemes (0.00003 lakh ha). The normal average annual rainfall of the district is 592.9 mm and seasonal rainfall of the district is shown in Fig. 1.13. The soils in the district is predominantly covered with black soil, red soil, sandy soil, sandy loam soil (Fig. 1.14). Crops grown during *kharif* and *rabi* season in the district are shown in Table 1.3. The district receives low rainfall with high-risk category. The district may experience increase in drought proneness as a future hazard and it may also experience rise in minimum temperature.

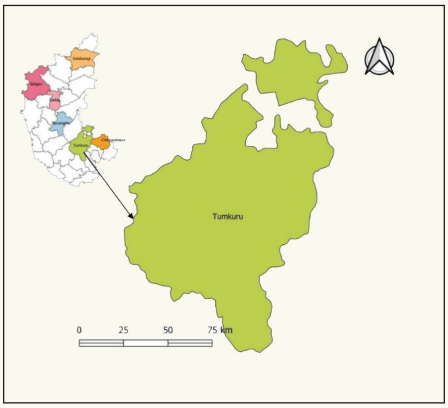


Fig. 1.11 Tumkuru district

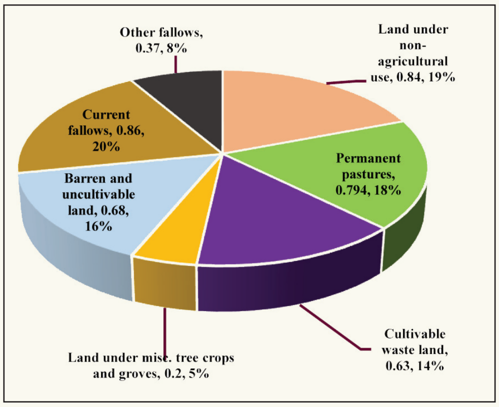


Fig. 1.12 Land use pattern (area in lakh ha)

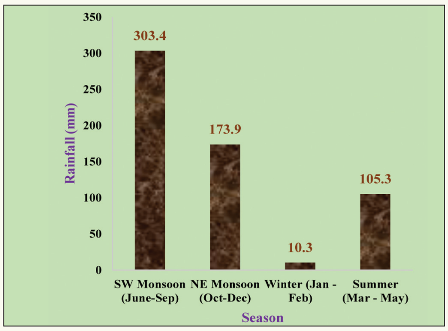


Fig.1.13 Season wise rainfall (mm)

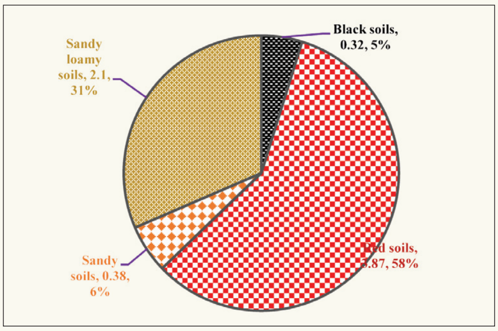


Fig. 1.14 Major soil classification (Area in lakh ha)

Table 1.3. Area wise and crop wise irrigation status at Tumkuru district

Crop type	Kharif (ha)			Rabi (ha)			Summer (ha)			Total		
	IRR	Rain-fed	Total	IRR	Rain-fed	Total	IRR	Rain-fed	Total	IRR	Rain-fed	Total
Cereal	27780	198664	226444	990	630	1620	7090	0	7090	35860	199294	235154
Coarse cereal	0	0	0	0	0	0	0	0	0	0	0	0
Pulses	230	69690	69920	0	5269	5269	175	0	175	405	74959	75364
Oil seeds	2422	140449	142871	20	70	90	2490	0	2490	4932	140519	145451
Fibre	1350	150	1500	150	0	150	0	0	0	1500	150	1650
Sericulture (Mulberry)	3958	0	3958	0	0	0	0	0	0	3958	0	3958
Horticulture crops	161229	53665	214894	0	0	0	0	0	0	0	0	0
Total	**196969**	**462618**	**659587**	**1160**	**5969**	**7129**	**9755**	**0**	**9755**	**46655**	**414922**	**461577**

(IRR - Irrigated)

1.3.4 Chikkaballapur

Chikkaballapur district lies in the eastern part of Karnataka and it lies between 13°13′ to 13°58′ N latitude and 77°21′ to 78°12′ E longitude with an altitude of 918 m above MSL (Fig. 1.15). The district falls under Eastern Ghats and Tamil Nadu uplands and Dry eco-subregion (8.1) of agro-ecological sub region, Southern Plateau and Hills region (X) of agro-climatic region and Eastern Dry Zone (KA-5) of agro-climatic zone. The geographical area of the district is 4.05 lakh ha, out of which, cultivable area is 1.71 lakh ha, forest area is 0.50 lakh ha and the other land use pattern of the district is shown in Fig. 1.16. Crops grown in the district under rainfed situation is 1.25 lakh ha and net irrigated area is about 0.46 lakh ha. The source of irrigation in the district are bore wells (0.38 lakh ha), open wells (0.013 lakh ha) and tanks (0.003 lakh ha). The normal average annual rainfall of the district is 743.2 mm and seasonal rainfall is shown in Fig. 1.17. The district is predominantly covered with red loamy soil, red sandy loam soils and laterite soil (Fig. 1.18). Crops grown during *kharif* and *rabi* season are shown in Table 1.4. The district receives low rainfall with high-risk category and may likely to experience increase in minimum temperature.

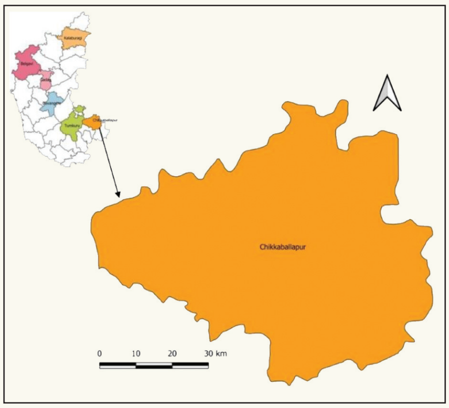


Fig. 1.15 Chikkaballapur district

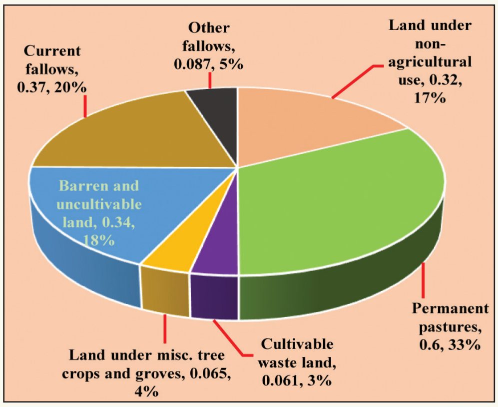


Fig. 1.16 Land use pattern (Area in lakh ha)

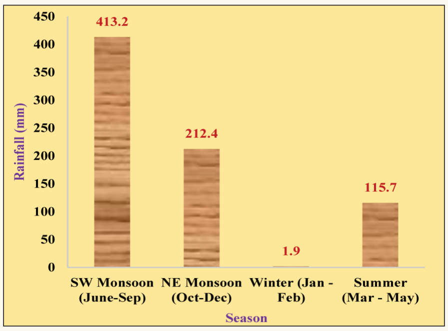


Fig. 1.17 Season wise rainfall (mm)

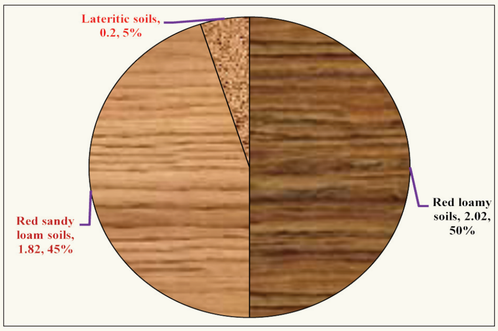


Fig. 1.18 Major soil classification (Area in lakh ha)

Table 1.4 Area wise and crop wise irrigation status at Chikkaballapur district

Crop type	Kharif (ha)			Rabi (ha)			Summer (ha)			Total		
	IRR	Rain-fed	Total	IRR	Rain-fed	Total	IRR	Rain-fed	Total	IRR	Rain-fed	Total
Cereal	13449	932211	106670	600	0	600	3300	0	3300	17349	932211	110570
Coarse cereal	0	150	150	0	0	0	0	0	0	0	150	150
Pulses	130	17070	17200	0	450	450	0	0	0	130	17520	17650
Oil seeds	700	28930	29630	800	0	800	2500	0	2500	4000	28930	32930
Fibre	150	0	150	0	0	0	0	0	0	150	0	150
Sericulture (Mulberry)	16581	0	16581	0	0	0	0	0	0	16581	0	16581
Others	200	0	200	0	0	0	0	0	0	200	0	200
Total	**31210**	**139371**	**170581**	**1400**	**450**	**1850**	**5800**	**0**	**5800**	**38410**	**139821**	**178231**

(IRR - Irrigated)

1.3.5 Davangere

Davangere district is located in central part of Karnataka between 13°50′ to 14°50′ N latitude and between 75°30′ to 76°30′ E longitude with an altitude of 657 m above MSL (Fig. 1.19). The district falls under Eastern Ghats and Tamil Nadu Uplands (8.2) of agro-ecological sub region, Deccan Plateau, Hot Semi-Arid Eco-Region (6.4) of agro-climatic region and Southern plateau and Hills region (X) of agro-climatic zone. The geographical area of the district is 5.98 lakh ha, out of which, cultivable area is 3.88 lakh ha, forest area is 0.90 lakh ha and the other land use pattern of the district is shown in Fig. 1.20. Crops grown in the district under rainfed situation is 2.42 lakh ha and net irrigated area is about 1.47 lakh ha. The source of irrigation in the district are canals (0.52 lakh ha), tanks (0.02 lakh ha), bore wells (0.83 lakh ha) and other sources (0.10 lakh ha). The normal average annual rainfall of the district is 650 mm and seasonal rainfall of the district is shown in Fig. 1.21. The district is predominantly covered with mixed red and black soils, red sandy soils, deep to medium deep black soils and sandy loam soils (Fig. 1.22). Crops grown during *kharif* and *rabi* season in the district as shown in Table 1.5. The district is under medium exposure to vulnerability with medium vulnerability index and the district falls under medium risk category due to climate change.

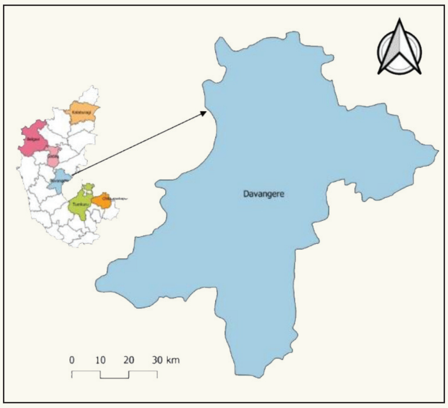


Fig. 1.19 Davangere district

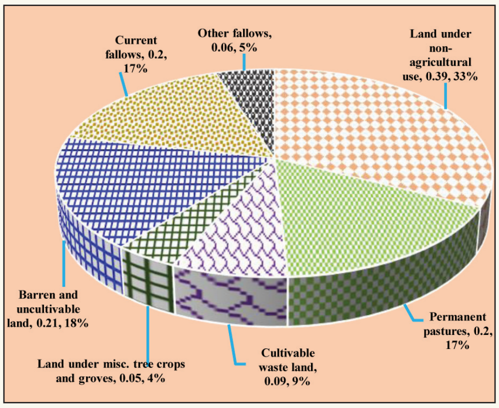


Fig. 1.20 Land use pattern (Area in lakh ha)

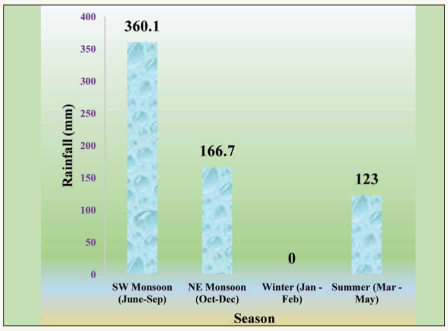


Fig. 1.21 Season wise rainfall (mm)

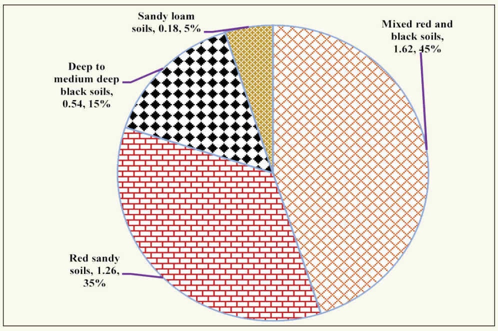


Fig. 1.22 Major soil classification (Area in lakh ha)

Table 1.5 Area wise and crop wise irrigation status at Davangere district

Crop type	Kharif (ha)			Rabi (ha)			Summer (ha)			Total		
	IRR	Rain-fed	Total	IRR	Rain-fed	Total	IRR	Rain-fed	Total	IRR	Rain-fed	Total
Cereal	93650	162850	256500	2585	10065	12650	40500	0	40500	136735	172915	309650
Pulses	2250	21600	23850	650	8800	9450	3400	0	3400	6300	30400	36700
Oil seeds	2100	24050	26150	1050	2450	3500	15100	0	15100	18250	26500	44750
Fibre and other crops	13500	20000	33500	1250	250	1500	3000	0	3000	17750	20250	38000
Total	**111500**	**228500**	**340000**	**5535**	**21565**	**27100**	**62000**	**0**	**62000**	**179035**	**250065**	**429100**

(IRR - Irrigated)

1.3.6 Belagavi

The Belagavi district is located in the east of the Western Ghats and is situated in north-western part of Karnataka state. It lies between 15°00′ to 17°00′ N latitude and 74°00′ to 75°30′ E longitude with an altitude of 836 m above MSL (Fig. 1.23). The district falls under Deccan Plateau, Hot Semi-Arid Eco-Region (6.4) of agro-ecological sub region, Southern Plateau and Hills Region (X) of agro-climatic region and Northern Transitional Zone (KA-8) of agro-climatic zone. The geographical area of the district is 13.44 lakh ha, out of which, cultivable area is 8.42 lakh ha, forest area is 1.90 lakh ha and the other land use pattern of the district is shown in Fig. 1.24. The area under net irrigation is 4.31 lakh ha and rainfed is 4.11 lakh ha. The source of irrigation in the district are bore wells (2.22 lakh ha), canals (0.91 lakh ha) and tanks (0.024 lakh ha). The normal average annual rainfall of the district is 823.3 mm and seasonal rainfall of the district is shown in Fig. 1.25. The district is predominantly covered with black soils, red soils, sandy soils and sandy loam soils (Fig. 1.26). Crops grown during *kharif* and *rabi* season in the district are shown in Table 1.6. The district has medium exposure to vulnerability with medium vulnerability index and it falls under medium risk category due to climate change.

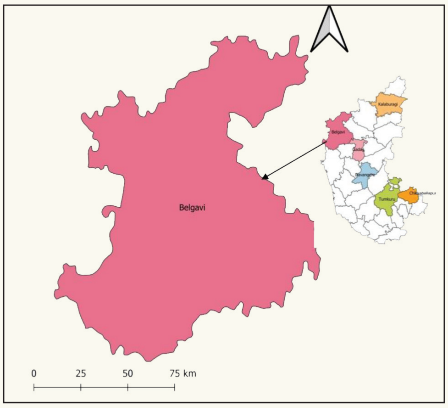


Fig. 1.23 Belagavi district

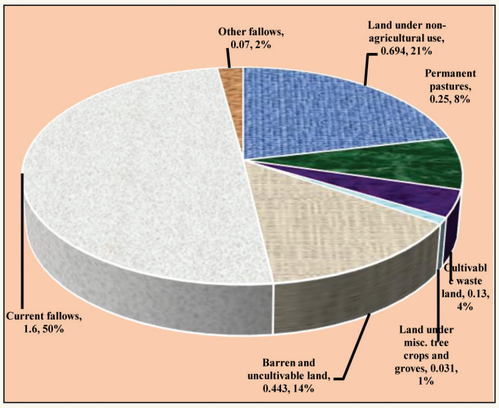


Fig. 1.24 Land use pattern (Area in lakh ha)

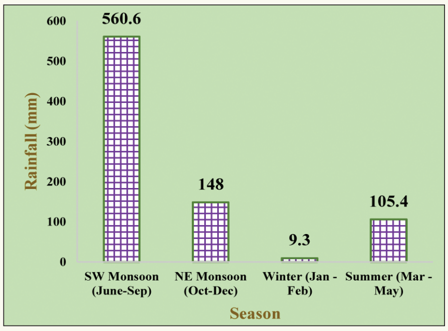


Fig. 1.25 Season wise rainfall (mm)

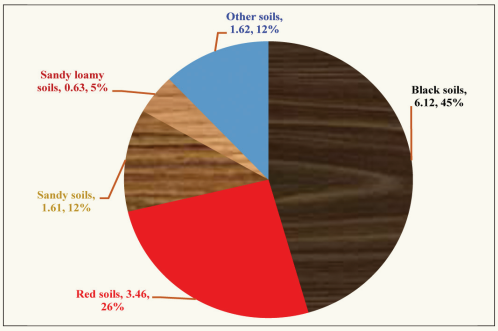


Fig. 1.26 Major soil classification (Area in lakh ha)

Table 1.6 Area wise and crop wise irrigation status at Belagavi district

Crop type	Kharif (ha)			Rabi (ha)			Summer (ha)			Total		
	IRR	Rain-fed	Total	IRR	Rain-fed	Total	IRR	Rain-fed	Total	IRR	Rain-fed	Total
Cereal	82329	135422	217751	82200	121108	203308	3016	0	3016	167545	256530	424075
Coarse cereal	5	1353	1358	0	0	0	0	0	0	5	1353	1358
Pulses	2128	37833	39961	26093	60411	86504	330	0	330	28551	98244	126795
Oil seeds	19469	98914	118383	4663	6265	10928	5600	0	5600	29732	105179	134911
Fibre	11111	24602	35713	0	0	0	35	0	35	11146	24602	35748
Tobacco + sugarcane	3720	224090	227810	0	177	177	0	0	0	3720	224267	227987
Horticulture plantation and vegetables	9908	12676	22584	10544	0	10544	12240	0	12240	32692	12676	45368
Total	**128670**	**534890**	**663560**	**123500**	**187961**	**311461**	**21221**	**0**	**21221**	**273391**	**722851**	**996242**

(IRR - Irrigated)

2. Promising Climate Resilient Technologies

2.1 Promising Climate Resilient Natural Resource Management Technologies

Farm ponds for lifesaving irrigation and minimizing the impact of drought

Details of technology: Farm pond is a dugout structure with definite size and shape having proper inlet and outlet structures and it collects the surface runoff from the farm or catchment. The stored water in the farm pond is used for supplemental irrigation during dry spells in order to reduce the impact of drought. The size of the farm pond mainly depends on rainfall, soil type, slope, water requirement, crop area etc., and usual size of the farm ponds constructed are 10 × 10 × 3, 12 × 12 × 3, 15 × 15 × 3, 20 × 20 × 3 m etc. The approximate cost involved for the construction ranges from Rs. 15000 to 45000 per farm pond and it may vary based on the size. Many farm ponds were constructed in Chikkaballapur (8), Davangere (42), Gadag (43), Kalaburagi (79) and Tumkuru (101) under NICRA and Krishi Bhagya Yojane.

Performance and impact: Farm ponds were constructed in D. Nagenahalli, S.Raguttahalli, Siddanuru, Mahalingapur and Melakunda (B) villages of Tumkuru, Chikkaballapur, Davangere, Gadag, and Kalaburagi districts respectively. Farm ponds helped to harvest 5576 to 56639 m^3 runoff in the NICRA villages during high rainfall events occurred during the monsoon season. The villages experienced dry spell during vegetative and maturity stages of the crops during 2018. Harvested water was utilized for critical irrigation in finger millet, maize, green gram and pigeon pea crops, which resulted in increase of crop yields up to 57, 56, 60 and 30%, respectively, compared to plots without critical irrigation and correspondingly additional return of Rs. 8890, 20250, 21670 and 12230 per ha was realized over the farmers' without farm pond (Table 2.1.1).

Table 2.1.1 Impact of farm ponds for critical irrigation in different NICRA villages of Karnataka

District	Intervention	Crop	Crop yield (q/ha)	Net return (Rs./ha)
Tumkuru	Farm pond	Finger millet	22	22870
	Without farm pond		14	13980
Chikkaballapur	Farm pond	Finger millet	17	19500
	Without farm pond		13	14150
Davangere	Farm pond	Maize	61	60750
	Without farm pond		39	40500
Gadag	Farm pond	Green gram	8	34250
	Without farm pond		5	12580
Kalaburagi	Farm pond	Pigeon pea	13	53800
	Without farm pond		10	41570

Upscaling: This technology can be promoted through Krishi Bhagya Yojana, State departments of agriculture, National Horticulture Mission (NHM) and under MGNREGS.

Farm ponds and critical irrigation for maize and green gram in NICRA villages of Karnataka

Desilting of community ponds for capacity augmentation and for providing critical irrigation during drought

Details of technology: Community ponds constructed long ago have become defunct due to silting up and non-maintenance, leading to less storage of water in the pond during monsoon. This leads to reduced recharge of groundwater in surrounding wells. Desilting of community pond increases the water storage. Desilting provided fertile silt, which was used by farmers in their fields, reduced the use of fertilizer. Desilting of community pond has been taken in Tumkuru, Davangere, Gadag, and Kalaburagi districts of Karnataka.

Performance and impact: Desilting of community pond has been taken in D. Nagenahalli, Siddanuru, Mahalingapur and Bilakundi villages of Tumkuru, Davangere, Gadag and Belagavi districts respectively. Rainfall in the villages ranges from 400 to 550 mm and the crop experiences frequent droughts during the growing season. Desilting has increased the storage capacity of village ponds up to 156500 m^3 in D. Nagenahalli, 7783 m^3 in Siddanuru, 4392 m^3 in Mahalingapur and 4500 m^3 in Bilakundi. This resulted in recharging of bore wells and increased the groundwater level by 3 to 5 m and benefitted 188 farmers in the villages. The harvested water was used for supplemental irrigation of finger millet, maize, green gram and groundnut crops during dry spell of more than 20 days coinciding with the vegetative and flowering stages of the crop. Supplemental irrigation helped to increase crop yields by 25 to 54% more compared to un-irrigated plots during dry spell. Additional net returns of Rs. 29400 per ha from groundnut, Rs. 19280 per ha from maize, Rs. 18660 per ha from green gram and Rs. 8050 per ha from soybean crop were realized as compared to crops without irrigation during dry spells (Table 2.1.2).

Table 2.1.2 Community ponds for supplemental irrigation in different NICRA villages of Karnataka

District	Intervention	Crop	Crop yield (q/ha)	Net return (Rs./ha)
Tumkuru	Community pond	Groundnut	17	21870
	Without		11	13980
Davangere	Community pond	Maize	58	59780
	Without		39	40500
Gadag	Community pond	Green gram	7	31240
	Without		5	12580
Belagavi	Community pond	Soybean	30	28900
	Without		24	20850

Upscaling: Upscaling of this technology can be done with the help of Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), IWMP and NABARD.

Desilting of community ponds and supplemental irrigation for groundnut and maize in NICRA villages of Karnataka

Desilting of check dam for minimizing the impact of drought

Details of technology: Check dams are small barriers built across the direction of water flow on natural nalas or drainage channels to minimize the erosion, reducing water flow velocity and also for water harvesting. These check dams built long back have become defunct due to silting up and non-maintenance, which resulted in reduced storage capacity. Desilting of check dam enhances the water storage capacity. The major benefit is replenishment of groundwater in the nearby wells. Desilting of check dam was taken up in the Tumkuru, Chikkaballapur, Davangere, Gadag and Kalaburagi districts of Karnataka.

Performance and impact: In D. Nagenahalli, S.Raguttahalli, Siddanuru, Mahalingapur and Melakunda (B) villages of Tumkuru, Chikkaballapur, Davangere, Gadag and Kalaburagi districts, respectively, desilting of check dams in NICRA villages enhanced the water storage capacity of check dams and also helped to improve the groundwater levels in nearby bore wells by 15 to 20 feet during post monsoon season. Recharged water was used to provide pre-sowing and supplemental irrigations to *rabi* crops. Crop yields of tomato, chickpea and sorghum increased by 12, 33 and 50%, respectively, as compared to farmers' practice and correspondingly additional net returns of Rs. 41830, 5950 and 4500 per ha was realized (Table 2.1.3). This technology helped to increase the groundwater level in 205 bore wells involving 205 farmers in the NICRA villages.

Table 2.1.3 Impact of desilting of check dams in different NICRA villages of Karnataka

District	Intervention	Crop	Crop yield (q/ha)	Net return (Rs./ha)
Tumkuru	Check dam	Tomato	359	236290
	Without check dam		321	194460
Belagavi	Check dam	Chickpea	8	24580
	Without check dam		6	18630
Gadag	Check dam	Sorghum	6	7500
	Without check dam		4	3000
Kalaburagi	Check dam	Chickpea	9	27445
	Without check dam		7	19580

Upscaling: Upscaling of this technology can be carried out with the help of Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), IWMP, NABARD and also through State Departments of Agriculture.



Desilting of check dam and supplemental irrigation for rabi crops

Percolation tank for water conservation and supplemental irrigation

Details of technology: Percolation tanks are constructed or built-in low-lying areas to store the runoff water and allow it to percolate down to replenish the groundwater level in the nearby wells. Percolation tanks replenish the groundwater during rainy season, reduces the velocity of water flow and it minimizes the soil erosion and floods in downstream areas. Construction and desilting of percolation tanks was taken in Tumkuru and Chikkaballapur to enhance the water storage capacity and recharge the groundwater.

Performance and impact: Desilted percolation tanks in D. Nagenahalli, and S.Raguttahalli villages of Tumkuru and Chikkaballapur, districts respectively. Desilting of percolation tanks in NICRA villages enhanced the water storage and helped to improve the groundwater levels in 20 bore wells by 15 to 20 feet during post monsoon season. Recharged water was used to give supplemental irrigation for finger millet and pigeon pea crops during dry spell occurred at tillering and pod formation stages during 2018. Supplemental irrigation increased finger millet yield by 35% and groundnut yield by 33% compared to un-irrigated plots and additional returns of Rs. 8250 per ha and Rs. 10170 per ha was realized (Table 2.1.4).

Table 2.1.4 Impact of desilting of percolation tanks on crop yields in different NICRA villages of Karnataka

District	Intervention	Crop	Crop yield (q/ha)	Net return (Rs./ha)
Tumkuru	Percolation pond	Pigeon pea	12	27520
	Without percolation pond		9	17350
Chikkaballapur	Percolation pond	Finger millet	23	22400
	Without percolation pond		17	14150

Upscaling: This intervention can enhance the surface water availability, increase the groundwater recharge which in turn enhances the groundwater availability in wells located nearer to the tanks. Upscaling of this technology can be carried out with the help of Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), IWMP and NABARD, on-farm trials by State Agricultural Universities, ATMA and also through State Departments of Agriculture.



Percolation tanks and supplemental irrigation in NICRA villages of Tumkuru and Chikkaballapur

Desilting of nala bunds for enhancing groundwater availability and critical irrigation during drought

Details of technology: Nala bunds are earthen embankments constructed across the main nalas or streams in arable and non-arable lands to store runoff for recharging ground water and make water available for agricultural use. The non-maintenance and silting up in nalas reduces the storage capacity of nala. Desilting of nalas helps to enhance the water storage capacity and water stored in the nalas helps to enhance the groundwater levels in nearby wells. The desilting of nala bunds was taken in Chikkaballapur, Belagavi and Kalaburagi districts of Karnataka.

Performance and impact: Desilting nala bunds was taken up in S.Raguttahalli, Bilakundi and Melakunda (B) villages of Chikkaballapur, Belagavi and Kalaburagi districts respectively. Desilting of nala bunds in NICRA villages enhanced the water storage and helped to recharge 58 bore wells by 10 to 15 feet during post monsoon season. Recharged water helped to give supplemental irrigation for finger millet, foxtail millet and pigeon pea crops during dry spell occurred in tillering and pod formation stages. The supplemental irrigation helped to increase the finger millet, foxtail millets and pigeon pea yield by 35, 25 and 18% respectively more compared to without irrigation and correspondingly additional net return of Rs. 8150, 5120 and 9500 per ha was observed (Table 2.1.5). This technology benefitted 58 farmers by recharging their bore wells in three NICRA villages.

Table 2.1.5 Impact of desilting of nala bunds in different NICRA villages of Karnataka

District	Intervention	Crop	Crop yield (q/ha)	Net return (Rs./ha)
Chikkaballapur	Nala bund	Finger millet	23	22300
	Without nala bund		17	14150
Belagavi	Nala bund	Foxtail millet	5	15820
	Without nala bund		4	10700
Kalaburagi	Nala bund	Pigeon pea	13	58500
	Without nala bund		11	49000

Upscaling: This technology can be upscaled with the help of Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), NABARD, on-farm trials by State Agricultural Universities (SAUs), ATMA and also through State Departments of Agriculture.

Desilting of nala bunds and supplemental irrigation during dry spells in NICRA villages

Artificial recharge structures for providing critical irrigation during drought/prolonged dry spells

Details of technology: Groundwater recharge structures are the most efficient and cost-effective structures to replenish the groundwater directly. A pit is opened around the bore well with 3-meter width, 3-meter length and 3-meter depth and small holes are made around the casing of the bore well. The pit is filled with layers of boulders, jelly stone, gravels and sand from bottom to top with specified height by leaving 2 feet free space to harvest rain water around the wells. Runoff water from the cultivated area is diverted towards bore well recharge unit through field trenches. This runoff water helps to enhance the ground water levels in the well. The artificial groundwater recharge structures were constructed in Chikkaballapur, Gadag, Belagavi and Kalaburagi districts.

Performance and impact: Recharge structures constructed increased the groundwater level by 20 to 25 ft, which in turn helped to give pre-sowing and supplemental irrigations. This technology helped to give supplemental irrigation for finger millet and green gram, and pre-sowing and supplemental irrigations for chick pea crops during *rabi* season. The crop yield enhanced by 33 to 60% compared to well without recharge structure. This technology helped to get an additional net return by Rs. 7600 per ha in finger millet, Rs. 22700 per ha in green gram and Rs. 7600 per ha in chickpea (Table 2.1.6).

Table 2.1.6 Impact of artificial recharge structures in different NICRA villages

District	Intervention	Crop	Crop yield (q/ha)	Net returns (Rs./ha)
Chikkaballapur	Recharge structure	Finger millet	22	21350
	Without recharge structure		16	13750
Gadag	Recharge structure	Green gram	8	35280
	Without recharge structure		5	12580
Belagavi	Recharge structure	Chickpea	8	26400
	Without recharge structure		6	18800
Kalaburagi	Recharge structure	Chickpea	8	26850
	Without recharge structure		5	19600

Upscaling: Recharge pits are generally constructed for recharging the shallow aquifers and is suitable for small catchment areas of 1000 m^2. The capacity of pit can be designed based on catchment area, rainfall intensity and recharge rate of soil. This technology can be upscaled by Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), CGWB, IWMP, NABARD.



Recharge structure and supplemental irrigation for green gram and chickpea in NICRA villages

Micro irrigation system in vegetables with harvested water for enhancing water use efficiency and crop productivity

Details of technology: Drip irrigation is a scientific method of irrigation distributes desired water directly to the root zone of the plant, drop by drop. The system has extensive network of pipes operated at low pressure. As a result of the low-application, water is applied slowly allowing it to be absorbed rather than quickly result in surface runoff. It reduced salinity hazards to plants, eliminated leaf damage caused by foliar salt absorption with sprinkler irrigation. Drip irrigation was demonstrated for vegetables in Tumkuru, Chikkaballapur and Davangere districts and sprinkler irrigation for groundnut and chickpea was adopted in Tumkuru and Kalaburagi districts respectively. The vegetables were maintained with a row to row spacing of 30-90 cm and plant to plant spacing of 10 to 30 cm. The approximate cost of sprinkler irrigation system for chickpea was about Rs. 30000/ha and drip irrigation system for vegetables was about Rs. 72000/ha.

Performance and impact: Micro irrigation system was demonstrated in D. Nagenahalli, S.Raguttahalli, Siddanuru and Melakunda (B) villages of Tumkuru, Chikkaballapur, Davangere and Kalaburagi districts respectively. Vegetables were taken in 66 ha area with drip irrigation and sprinkler irrigation in 30 ha area with groundnut and chickpea crops. Micro irrigation system helped in saving water by 30 to 50% as compared to surface method of irrigation. Drip irrigation system in vegetables resulted in increase of average yield up to 22% more with an additional net return of Rs. 45707 per ha compared to surface method of irrigation. Sprinkler irrigation in groundnut and chickpea helped to increase the yield by 42 and 30% respectively more compared to surface irrigation and correspondingly obtained additional net return of Rs. 18990 and Rs. 15190 per ha compared to farmers' practice (2.1.7).

Table 2.1.7 Micro irrigation systems for vegetables and *rabi* crops in NICRA villages of Karnataka

Village	Intervention	Crop	Yield (q/ha)	Net return (Rs./ha)
D. Nagenahalli	Drip Irrigation	Brinjal	210	102500
	Surface method		150	64150
	Sprinkler Irrigation	Groundnut	17	36240
	Surface method		12	17250
S.Raguttahalli	Drip Irrigation	Tomato	359	236290
	Surface method		321	194460
Siddanuru	Drip Irrigation	Tomato	315	215840
	Surface method		280	158900
Melakunda (B)	Sprinkler Irrigation	Chickpea	13	36870
	Surface method		10	21680

Upscaling: Adoption of this technology increases the crop growth and yield even in drought years and saves from crop failure. This technology can be promoted under National Horticulture Mission (NHM), PMKSY and also by State Governments by providing subsidy.



Micro irrigation for brinjal and tomato in NICRA villages of Tumkuru and Davangere

Mulching of sugarcane trash in Arecanut for enhancing water productivity in frequently drought prone regions

Details of technology: A mulch is a layer of material applied to the surface of soil. Reasons for applying mulch includes conservation of soil moisture, improving fertility and health of the soil and reducing weed growth. The sugarcane mulching in arecanut was adopted in Davangere district of Karnataka. Around 3 tons of sugarcane trash was used for spreading in one acre of arecanut field and 5-6 labor per ha was needed for spreading the mulch. The cost of spreading the arecanut mulch per acre is about Rs. 5000 to 6000.

Performance and impact: In Siddanuru village of Davangere district of Karnataka, sugarcane trash mulching with sprinkler irrigation in arecanut was demonstrated in 31 ha area involving 26 farmers in the village. Farmers earlier used drip and flooding method of irrigation for arecanut, but the moisture retention was very less due to high temperature. The sugarcane trash mulching conserved more moisture, controls temperature and reduce evaporation. Mulching helped to minimize the cost involved for weed management and weedicide application. Mulching in arecanut enhanced the yield up to 32 q/ha and net returns up to Rs. 1290000 per ha.

Upscaling: Crop residue mulching in arid and semi-arid regions in summer is known to be beneficial for crop production. This reduces the soil temperature, influences the biological process and enhances soil N mineralization. Residue mulching can be easily implemented by farmers because material is easily available, low cost and improves the soil. This technology can be upscaled through mission for Integrated Development of Horticulture.

Sugarcane trash mulching for arecanut in Siddanuru village of Davangere, Karnataka

Trench cum bund for enhancing the soil moisture storage and to minimize the impact of dry spells and drought

Details of technology: Trench cum bunds are artificial depressions and embankments made on the field and are generally rectangular or trapezoidal in section, which minimize soil erosion. Trench cum bunds can be used to store runoff water, there by more water infiltrates into the soil and makes available moisture for longer periods. The trench cum bund technology was demonstrated in Tumkuru, Chikkaballapur, Davangere and Belagavi districts with a general dimension of 5 m length, 1 m width and 0.6 m width by leaving one-meter berm between each trench.

Performance and impact: Trench cum bunds were constructed in D. Nagenahalli, S.Raguttahalli, Siddanuru and Bilkundi villages of Tumkuru, Chikkaballapur, Davangere and Belagavi districts respectively, covering an area of 378 ha benefitting 596 farmers. The trench cum bunds helped to reduce soil erosion and store rain water in trenches, resulting in conserving soil moisture for longer days. Trench cum bund helped to enhance the yield of pigeon pea, groundnut and maize by 29, 25 and 31% respectively more compared to cases without trench cum bund. Additional net return of Rs. 12380 to 22490 per ha was obtained as compared to farmers' practice (2.1.8).

Table 2.1.8 Impact of trench cum bunds for soil moisture conservation and to improve the crop productivity in NICRA villages

District	Intervention	Crop	Crop yield (q/ha)	Net return (Rs./ha)
Tumkuru	TCB (Trench cum bund)	Groundnut	15	33780
	Without TCB		12	21400
Chikkaballapur	TCB	Pigeon pea	27	48685
	Without TCB		21	26195
Davangere	TCB	Maize	47	28900
	Without TCB		39	15800
Belagavi	TCB	Maize	58	35900
	Without TCB		44	20250

Upscaling: This technology can be up scaled through MGNREGS and also through watershed development programs.

Trench cum bunds for soil moisture conservation and to increase the crop productivity during drought situations

Field/Farm bunds for soil and water conservation and minimizing the impact of dry spells

Details of technology: Farm bunds are constructed along the boundaries of the individual farmers' field with the purpose of arresting soil erosion and storing the water in plot itself. Farm bunds control the volume and velocity of runoff and also breaks the momentum of the water. Farm bund improves soil moisture storage. This technology was demonstrated in Kalaburagi district. The general specifications of farm bunds are 0.6 m height, 1.7 m base width with cross section area of 0.57 square meter and unit cost comes to around Rs. 8000 per ha.

Performance and impact: In Melakunda (B) village of Kalaburagi district, farm bunding was taken up in the year 2018, which helped to conserve moisture and reduced the loss of top fertile soil. The water stored behind the bunds helped to conserve more moisture for longer periods resulted in minimizing the effect of moisture stress during dry spells in pigeon pea. It improved the groundwater levels by increasing the infiltration and the technology was adopted in 22 ha involving 10 farmers. Farm bunding in pigeon pea crop increased the yield by 2 q/ha as compared to without bunding. The additional net return of Rs. 8000 per ha was realized over the farmers' practice (Table 2.1.9).

Table 2.1.9 Impact of farm bunds on soil moisture conservation and to improve crop productivity in Melakunda (B) village of Kalaburagi

District	Intervention	Crop	Crop yield (q/ha)	Net return (Rs./ha)
Kalaburagi	Farm bund	Pigeon pea	13	57000
	Without farm bund		11	49000

Upscaling: This technology can be up scaled to larger extent in the region by making the bund maker available through custom hiring centers and demonstrations by KVK and State Department of Agriculture. The earth works can be taken up under MGNREGS and also through watershed development programs.

Farm bunding in pigeon pea for moisture conservation in Melakunda (B) village of Kalaburagi

Deep summer ploughing for enhancing the soil moisture storage and crop productivity in frequently drought prone regions

Details of technology: Deep summer ploughing is ploughing the field across the slope during hot summer with the help of specialized tools with primary objective of breaking of the soil pans. Deep summer ploughing with MB plough after the pre-monsoon rainfall (during May) helps to recharge the soil profile. It facilitates to sow the crops immediately after onset of southwest monsoon. Off season tillage increases the water content of soils, reduces runoff and exposes the insects hiding underground to birds and other natural enemies. Summer ploughing is ploughing to a depth > 50 cm as compared to ordinary ploughing which rarely exceeds 20 cm. This technology was demonstrated in NICRA village of Belagavi district. The cost involved for the ploughing one-hectare area is about Rs. 2500.

Performance and impact: Summer deep ploughing was taken up in 25 ha involving 35 farmers. The crops taken in the deep ploughed fields were foxtail millet and black gram. During the cropping season of cluster bean and bajra crops experienced dry spells of more than 20 days during tillering and flowering stages in Bilkundi village. The crops in the summer deep ploughing fields experienced less water stress during dry spells as compared to non- ploughed fields. This intervention helped to improve the crop yield by one and 2.5 q/ha in foxtail millet and black gram crops respectively and correspondingly obtained additional returns of Rs. 5520 and Rs. 10835 per ha respectively as compared to fields without summer deep ploughing (Table 2.1.10).

Table 2.1.10 Impact of summer deep ploughing on crop productivity in Bilkundi village of Belagavi

District	Intervention	Crop	Crop yield (q/ha)	Net return (Rs./ha)
Belagavi	Summer deep ploughing	Foxtail millet	5.0	15820
	Farmers' practice		4.0	10300
	Summer deep ploughing	Black gram	10.5	31635
	Farmers' practice		8.0	20800

Upscaling: Summer deep ploughing (Off season tillage) increases the moisture content of soils, reduces the runoff, pest and weed infestation. Further, this technology can be promoted through developmental programmes such as NFSM.

Summer deep ploughing for black gram and foxtail millet in Bilkundi village of Belagavi

Compartmental bunding in sorghum to conserve moisture and to minimize moisture stress in drought prone regions

Details of technology: The entire field is divided into small compartments with pre-determined size to retain rain water where it falls and to arrest the soil erosion. The compartmental bunds were made using bund former. The size of the bunds depends on the slope of the land. Compartmental bunds provide more opportunity time for water to infiltrate into the soil and helps in conserving soil moisture. Each compartment behaves like an individual catchment and also breaks the length of the slope, which stores the water for longer time and also reduces the flow of water and erosion. Compartmental bunding technology was demonstrated in Gadag, Belagavi and Kalaburagi districts of Karnataka. The general specifications of compartmental bunding was 5 m x 5 m or 10 m x 10 m with bund height of 30 cm. The animal drawn bund former equipment was used in sorghum and the approximate cost of making compartmental bunding was Rs. 1250 per ha.

Performance and impact: Compartmental bunding was demonstrated in Mahalingapur, Bilakundi and Melakunda (B) villages of Gadag, Belagavi and Kalaburagi districts respectively. Sorghum was grown in the *rabi* season under compartment bund system of different sizes. Among them, 5x5 m and 10x10 m were found as best practices for efficient management of in-situ moisture in vertisols which significantly increased the grain yield, water use efficiency, and water productivity. Compartmental bunds are constructed for *rabi* sorghum in 88 ha area involving 220 farmers in the NICRA villages. The compartmental bunds are prepared during the month of August, which helped to harvest the rainfall, conserve moisture uniformly over the land and increased the rainwater use efficiency. The sorghum yield in compartmental field increased by 21 to 36% more as compared to without compartmental bunding and an additional net return of Rs. 4900 to 11440 was realized over the farmers' practice (Table 2.1.11).

Table 2.1.11 Compartmental bunds for soil moisture conservation for *rabi* crops in NICRA villages of Karnataka

District	Intervention	Crop	Crop yield (q/ha)	Net return (Rs./ha)
Gadag	Compartmental bunds	Sorghum	12	21800
	Farmers' practice (No bund)		09	16900
Belagavi	Compartmental bunds	Sorghum	15	31750
	Farmers' practice (No bund)		11	21144
Kalaburagi	Compartmental bunds	Sorghum	17	50840
	Farmers' practice (No bund)		14	39400

Upscaling: Compartmental bunding is low cost, more beneficial in medium to deep black soils with high clay content and low infiltration rate. Upscaling of this technology can be done through developmental programmes such as NFSM.

Compartmental bunding for rabi sorghum in Gadag, Belagavi and Kalaburagi districts of Karnataka

Broad bed furrow system for enhancing water use efficiency and crop productivity in drought prone regions

Details of technology: Broad bed furrow (BBF) helps to conserve moisture, increases infiltration and reduces runoff and soil erosion. BBF technology was demonstrated at Chikkaballapur district of Karnataka by using BBF implement with a broad bed width of 150 cm, furrow width of 45 cm and furrow depth of 20 cm. Furrows provides effective drainage during excess rain, retains moisture during dry spells and reduces the effect of extreme situations with increase in yield and additional income. The cost of BBF implement is nearly Rs. 35000 and the cost of making of broad bed furrows system was about Rs. 1500 per ha. Crops cultivated with broad bed furrow was ground nut + pigeon pea in Chikkaballapur district of Karnataka.

Performance and impact: The furrows created under BBF provides effective drainage during excess rains, while conserving soil moisture. Broad bed furrow increased the water use efficiency. It requires 15-20% less seed rate. The broad bed and furrow method of sowing in S.Raguttahalli village of Chikkaballapur district of Karnataka was demonstrated in 46 ha involving 137 farmers. Broad bed furrow technology in ground nut + pigeon pea enhanced the rain water use efficiency (RWUE) and economic water use efficiency (EWUE) by 18.75% and 85.50%, respectively compared to local practice of flatbed method and the additional net returns of ground nut + pigeon pea crop increased by 85.62 % compared to local check (Table 2.1.12).

Table 2.1.12 Broad bed furrows for enhancing water use effeciency in S.Raguttahalli village of Chikkaballapur

Locations	Crop	Crop yield (q/ha)		RWUE (kg/ha-mm)		Net returns (Rs/ha)		EWUE (Rs/ha-mm)	
		Local	BBF	Local	BBF	Local	BBF	Local	BBF
Chikkaballapura	Groundnut + Pigeon pea	7.10	8.65	3.2	3.8	6520	12103	29.0	53.8

Upscaling: The BBF technology reduced water stress, increased rain water use efficiency and resulted in better yield. This technology can be further promoted through demonstrations by KVKs, ATMA and extension functionaries. Adoption can also be increased by making the implement available through custom hiring centers.

Broad bed furrow in ground nut + pigeon pea in Chikkaballapur district of Karnataka

Ridge and furrow in pigeon pea for *in-situ* conservation and minimizing the impact of drought

Details of technology: The ridge and furrows are made by shaping the soil surface with alternate ridges and furrows along the length of a field. The ridges (60 cm wide) served as plating zone and furrows (60 cm wide) served as rainwater harvesting zone. Ridges and furrows thus formed act as continuous barrier to the movement of water, forcing the water downwards and provides more infiltration time, which improves the rainwater use efficiency. This system is advantageous for improving rainwater use efficiency and crop yields. This technology was demonstrated in Kalaburagi district of Karnataka.

Performance and impact: The ridge and furrow system was demonstrated for pigeon pea. In Kalaburagi district, pigeon pea experienced more than 15-days dry spell during flowering stage in 2018. The ridge and furrow adopted minimized the moisture stress in pigeon pea during dry spells as compared to flatbed method. The pigeon pea yield increased by 3 q/ha in ridge and furrow system as compared to farmers' practice and additional net return of Rs. 9500 per ha was obtained (Table 2.1.13). This technology was demonstrated in 80 ha area involving 68 farmers in the Melakund (B) village during the year 2018.

Table 2.1.13 Impact of ridges and furrows in Melkund (B) village of Kalaburagi

District	Intervention	Crop	Crop yield (q/ha)	Net return (Rs./ha)
Kalaburagi	Ridges and furrows	Pigeon pea	13	51500
	Farmers' practice		10	42000

Upscaling: This technology can be up scaled to larger extent in the region by making available the ridger plough equipment through custom hiring centers and demonstrations by KVK and State Department of Agriculture.

Ridge and furrow system in pigeon pea in Melkunda (B) village of Kalaburagi, Karnataka

Conservation furrow for *in-situ* moisture conservation and for minimizing the impact of drought

Details of technology: The conservation furrows were opened between the crop rows. The water harvested in the furrows makes moisture available for longer periods, and hence, crops can survive during dry spells. The general specification of conservation furrow was 40 cm furrow width and 20 cm depth of furrow. The bullock drawn ridge plough was used for the opening of conservation furrows and the cost of preparation was around Rs. 2200 per ha. Conservation furrow was demonstrated in Gadag district of Karnataka. The technology is suitable for low rainfall regions, in medium to deep black soils.

Performance and impact: In Mahalingapur village of Gadag, conservation furrow was demonstrated in green gram + pigeon pea and maize + pigeon pea. Conservation furrows opened 40 days after sowing helped to conserve moisture for longer days by increasing infiltration and water storage. The yield of the resilient intercropping system with conservation furrow was 25 to 38% more as compared to farmers' practice and an additional net return of Rs. 4079 to 7122 per ha was realized over the no conservation furrow. This technology was adopted in 100 ha area involving 250 farmers in the village during 2018.

Upscaling: This technology can be upscaled in this region by large scale demonstration with the aid of KVK's, line departments and also by promotion of the need-based implements through custom hiring centers.



Conservation furrows for intercropping system of green gram + pigeon pea and maize + pigeon pea in Mahalingapur village of Gadag, Karnataka

Land levelling for uniform moisture distribution and minimizing the impact of dry spells

Details of technology: Land levelling is the process of modifying existing slopes or undulations and thereby creating a level surface for uniform moisture distribution and its availability to crop. Land leveling requires excavation and movement of earth from higher elevations to lower elevations. The operations are usually accomplished using special equipment to eliminate the minor irregularities but not to change the general topography of the land surface. Levelling technology saves irrigation water and facilitates field operation, conserves moisture and increases the yield. The land levelling technology was taken in Tumkuru district. The approximate cost involved for land levelling was about Rs. 4500 per ha.

Performance and impact: In D. Nagenahalli village of Tumkuru district, land levelling was taken up in 32 ha area involving 62 farmers during 2018-19. The finger millet and paddy crop were taken up in the levelled land, which resulted in efficient and less use of inputs as compared to undulated land. The finger millet and paddy yield increased by 35 and 23 per cent respectively more as compared to earlier practice and correspondingly an additional return of Rs. 9476 and 7343 per ha was realized over the farmers' practice (Table 2.1.14).

Table 2.1.14 Impact of land levelling in D. Nagenahalli village of Tumkuru

District	Intervention	Crop	Crop yield (q/ha)	Net return (Rs./ha)
Tumkuru	Land levelling	Finger millet	27	33810
	Farmers' practice		20	17704
	Land levelling	Paddy	32	23520
	Farmers' practice		26	16177

Upscaling: This technology can be promoted through demonstrations by KVKs, ATMA and extension functionaries. Further, for faster adoption, this implement can be made available through custom hiring centers.



Laser land levelling for uniform moisture distribution in D. Nagenahalli village of Tumkuru

Application of tank silt to increase the moisture holding capacity and fertility of the soil in drought prone regions

Details of technology: Tank silt is a fine soil brought from surface runoff during rainfall from farm land or catchment area along with crop residues and is deposited as sediment in the tank water spread area and is decomposed over a period of time. This silt is rich in organic matter. The application of tank silt on farm land improves the physical, chemical and biological properties of the soil and also enhances the water holding capacity of the soil. Tank silt application to farm land improves the crop yield and also increases the income generation. The tank silt excavated from the water harvesting structure was applied in Tumkuru and Kalaburagi districts. The approximate cost of tank silt application to farm land is Rs. 12000 per acre.

Performance and impact: In D. Nagenahalli and Melkunda (B) villages of Tumkuru and Kalaburagi districts, 5000 tons of tank silt was excavated and applied to the 24-ha area benefitting 63 farmers during 2018. The tank silt applied improved the physical and chemical properties of the soil, enhanced the water holding capacity and improved the moisture availability for longer duration as compared to without tank silt applied field. The finger millet and pigeon pea crops were taken in the tank silt applied field, which resulted in an additional yield by 3 and 4 q/ha respectively and correspondingly an additional net return of Rs. 6470 and Rs. 25610 per ha over the farmers' practice (Table 2.1.15).

Table 2.1.15 Impact of application of tank silt in D. Nagenahalli and Melkunda (B) villages of Karnataka

District	Intervention	Crop	Crop yield (q/ha)	Net return (Rs./ha)
Tumkuru	Silt application	Finger millet	14	20750
	Farmers' practice		11	14280
Kalaburagi	Silt application	Pigeon pea	20	47500
	Farmers' practice		16	21890

Upscaling: Application of tank silt improved the soil moisture, enhanced water holding capacity as well as increased the aeration, porosity and nutrient status of the soil. Upscaling of the technology can be done as part of Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) and other programmes aiming at augmentation of water bodies in the village.

Tank silt application to improve soil fertility in D. Nagenahalli and Melkunda (B) villages, Karnataka

Green manuring to enhance soil health in frequently drought prone regions

Details of technology: Improving soil fertility in rainfed regions is a challenge and also important for sustainable agriculture production. Green manuring can play an important role in this regard by improving soil physico-chemical and biological properties, nutrient supply to succeeding crops, minimizing erosion and by enhancing the water holding capacity of the soil. Green manuring with *sun hemp* and *Dhaincha* was demonstrated in Belagavi and Davangere districts of Karnataka. The approximate cost of growing the green manuring crop was about Rs. 2500 per ha.

Performance and impact: The green manuring crop *sun hemp* and *Dhaincha* was taken up in Bilakundi and Siddanuru villages of Belagavi and Davangere districts respectively. Green manuring crop produced biomass of 25 to 30 ton per ha and the incorporation of biomass resulted in improvement of nutrients content in the soil. This technology enhanced the water holding capacity and organic matter content of the soil and improved the crop productivity. The sorghum and areca nut yield increased by 3 q/ha and 2 q/ha respectively, as compared to without green manuring field. The adoption of green manuring technology increased the average net return up to Rs. 3500 per ha from sorghum crop and Rs. 71000 per ha from arecanut (Table 2.1.16).

Table 2.1.16 Effect of green manuring with sun hemp and *Dhaincha* for sorghum and arecanut in NICRA villages of Karnataka

Village	Intervention	Crop	Yield (q/ha)	Net return (Rs./ha)
Bilakundi	Farmers' practice	Sorghum	12	14500
	Green manuring		9	11000
Siddanuru	Farmers' practice	Areca nut	27	796000
	Green manuring		25	725000

Upscaling: This technology can be upscaled through convergence with programme being taken up by Department of Agriculture.

Green manuring to enhance the crop productivity in TDC-NICRA villages

2.2 Promising Climate Resilient Crop Production Technologies

Finger millet variety ML-365 for early maturity and to escape drought for South Karnataka region

Details of technology: Finger millet is the staple food for majority of South Karnataka. It is cultivated by small and marginal farmers as rainfed as well as irrigated crop. Farmers of this region cultivate local (GPU-28) and long duration varieties of finger millet realising low yield. Low productivity is due to delayed onset of monsoon, low and erratic rainfall. To cope with the climatic variabilities, medium duration and drought tolerant variety of finger millet ML-365 was demonstrated in the villages during *kharif* season. The variety has a duration of 105-110 days with high grain and fodder yield. The variety was demonstrated in various locations of Chikkaballapur, Tumkur and Davangere districts. The variety is suitable for rainfed and delayed sowing conditions. It is also resistant to leaf spot, neck blast disease and lodging.

Performance and impact: In S. Raguttahalli village, there was a deficit of 34-50% rain during 2014, 2016 and 2018. D. Nagenahalli village experienced long dry spells in June-July during 2011, 2012, 2015, 2017 and 2018. To minimize the impact of low rainfall and dry spells, finger millet ML-365 variety was demonstrated in NICRA villages. Significant improvement in yield was observed upto 36-39% compared to the local variety. The variety (ML-365) performed well and can withstand the dry spells with grain yield of 13.8-26.5 q/ha compared to local variety (GPU-28) in D. Nagenahalli and Siddanuru villages during drought periods. In S. Raguttahalli village, the variety (ML-365) performed well with grain yield of 4.2 q/ha during the drought year. Under normal rainfall situations, grain yield of ML-365 was 10.5 q/ha. The yields obtained are higher when ML-365 was provided one critical irrigation. The resilience achieved was 60-81% due to adoption of ML-365 in various locations and minimised the yield loss during the drought year (Table 2.2.1).

Table 2.2.1: Performance of drought tolerant ML-365 during drought year in South Karnataka region

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Tumkur				
Farmers' practice : GPU-28	10.5	20830	27300	6470
Improved variety: ML-365	14.6	21650	37960	16310
Davangere				
Farmers' practice : Local variety	22.5	36200	56750	20550
Improved variety: ML-365	26.5	35000	65650	30650

Upscaling: Finger millet variety ML-365 was adopted in 200 ha area in NICRA village of Chikkaballapur district and upscaled to 3641 ha in the district. The variety can be further spread through convergence with programmes such as NFSM.

Drought tolerant finger millet variety ML-365, in NICRA villages of Tumkur and Davangere districts

Stress tolerant pigeonpea cultivar TS-3R for semi-arid regions of Karnataka

Details of technology: Moisture stress and early and mid season droughts occur in semi-arid regions of Karnataka state particularly in Belagavi and Kalaburagi districts. Medium duration varieties were introduced to minimize the impact of dry spells in these regions. Among the major crops, pigeonpea was cultivated in larger area as a sole crop and inter crop. Earlier, farmers cultivated local, long duration (200 days), moisture stress and wilt prone Gulyal variety of pigeonpea. Under NICRA programme, medium duration (150 days), drought tolerant, wilt resistant and high yielding variety of pigeon pea, TS-3R with improved practices was introduced. The variety TS-3R can withstand the long dry spells at early and mid seasons. Pigeon pea variety (TS-3R) with improved production technologies gave higher yield per ha than that of farmers' practice. Medium duration variety performed well during early and mid-season droughts at vegetative stages (2012 and 2015).

Performance and impact: Yadagud and Melakunda (B) villages received deficit rainfall of 37-60% coupled with dry spells of 20-45 days during June to October months during 2015. Early and mid season droughts impacted the local varieties resulting in crop failure and low grain yields. In Yadagud village, Belagavi district improved variety (TS-3R) achieved higher yield of 82.7% under drought situations whereas, during normal rainfall years an average yield of 15.2 q/ha was realised compared to yields of local Gulyal variety 8.1q/ha with an additional net income of Rs.59748/ha (Table 2.2.2).

Table 2.2.2: Productivity of drought tolerant Pigeon pea variety TS-3R during stress year in Yadagud village, Belagavi district

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Farmers' practice: Gulyal variety	7.5	15850	42560	26710
Improved variety: TS 3R	13.7	18000	77748	59748

Upscaling: This variety is suitable for areas which experience frequent early and mid season droughts. The variety can be upscaled under various state and central government programmes.

Drought tolerant pigeonpea variety TS-3R in Melakunda (B) village of Kalaburagi district

Short duration and drought tolerant wheat variety DWR-2006 for drought prone regions of Karnataka

Details of technology: Deficit rainfall coupled with high temperatures, moisture stress due to low rainfall and terminal stress in *rabi* crops are the major constraints of Belagavi district. Due to deficit rainfall, high temperatures and moisture stress yields of wheat are generally low in the region. Short duration and drought tolerant wheat variety DWR-2006 can tolerate the deficit rainfall and higher temperatures. It is of 90-100 days duration. This short duration variety can escape the terminal drought and minimised risk due to moisture stress and can be grown under limited moisture conditions.

Performance and impact: Yadagud village, has a deficit of 30-60% rainfall with long dry spells of 15-45 days during the years, 2016-19 along with 8-15 rainy days. DWR-2006 wheat variety was found suitable for rainfed situation as it has tolerance to moisture stress. Variety DWR-2006 recorded a higher yield of 32% when compared to farmer's practice of using DWR-162 (13.3 q/ha) variety with additional income of Rs.11070/ha during the drought year. The DWR-2006 variety can attain potential yields when provided with 2-3 protective irrigations (Table 2.2.3).

Table 2.2.3: Yield obtained from drought tolerant wheat variety DWR-2006 during deficit rainfall year in Yadagud village, Belagavi district

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Farmers' practice : DWR-162	13.3	16500	39750	23250
Improved variety: DWR-2006	17.5	18300	52620	34320

Upscaling: This improved variety is well suited to areas where terminal moisture stress and high temperature frequently occur and also with limited irrigations with harvested water. With the support of State Department and NFSM the variety can be spread to larger area in Belagavi district.

Short duration and drought tolerant variety DWR-2006 in Yadagud village at Belagavi district

Medium duration pigeonpea varieties for semi-arid regions of Karnataka to minimize the impact of moisture stress

Details of technology: Low and erratic rainfall with frequent dry spells, high temperatures with recurrent droughts are the major constraints of Chikkaballapur and Davangere districts. Pigeon pea is the main *kharif* crop in the district. Yield losses can be minimized by introducing medium duration pigeon pea varieties (BRG-1, BRG-2 and BRG-5) which can escape the terminal moisture stress conditions which limits yields of long duration pigeon pea. Medium duration varieties can minimize the impact of moisture stress during the crop period and increases yield. The BRG-5 is released in the year 2015 by UAS, Bengaluru and comes to maturity in 160-170 days duration. BRG-2 is notified in the year 2009 by UAS, Bengaluru which is of 175-185 days duration.

Performance and impact: Siddanuru and S.Raguttahalli villages received a deficit rainfall of 19-65% with less number of rainy days during 2011, 2012, 2016 and 2018 years. Prolonged dry spells were frequent in both the villages creating moisture stress situation for the crop. Medium duration varieties of pigeon pea were demonostrated farmers which can tolerate the long dry spells. Improved varieties BRG-1, BRG-2 and BRG-5 obtained seed yield of 10-12 q/ha with yield improvement of 28.5% compared to local varieties in normal year. In the drought year, the varieties obtained a yield of 8-10 q/ha. The resilience obtained is about 81% due to adoption of improved varieties compared to local varieties under stressed condition (Table 2.2.4).

Table 2.2.4: Yield of drought tolerant pigeonpea variety BRG-2 during drought year

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Tumkur				
Farmers' practice : local variety	4.7	22130	26461	4331
Improved variety: BRG-2	5.6	22380	31528	9148
Davangere				
Farmers' practice : local variety	9.39	23174	39579	37405
Improved variety: BRG-2	11.26	23843	47461	23618

Upscaling: The medium duration varieties can withstand long dry spells. The variety was adopted in 570 ha in NICRA cluster of villages Chikkaballapur district. The variety can be expanded to larger area by forging convergence with be programmes such as NFSM.

BRG-1 variety in Chikkaballapur district

BRG-2 variety in Tumkuru district

BRG-2 variety in Davangere district

Intercropping of Groundnut + Pigeon pea for minimising the risk

Details of technology: NICRA villages of Chikkaballapur and Tumkuru district receives rainfall of <700mm. Farmers grow sole crop of groundnut during *kharif* season and face problem of moisture stress during the cropping period. Sometimes, severe moisture stress results in failure of crop thus resulting loss of income. To overcome this, intercropping of Groundnut (K-6) + Pigeon pea (BRG-1)- 10:2 (Chikkaballapur) and Groundnut + Pigeon pea - 8:2 (Tumkuru) were introduced in the district for higher productivity. The intercropping systems has reduced the risk of crop failure. Intercropping systems contribute to efficient use of resources, improved soil fertility, improved nitrogen status of soil through atmospheric nitrogen fixation and improved organic matter in soil.

Performance and impact: In S.Raguttahalli village, during the years 2014, 2016 and 2018 there was a deficit of 50%, 34% and 42% rainfall respectively. Groundnut + Pigeon pea (10:2) intercropping system was demonstrated for minimizing the impact of dry spells and to enhance resilience. Equivalent yield of 5.12 q/ha was obtained from intercropping compared to 3.54 q/ha of sole cropping (Groundnut) during the drought year of 2018-19. In normal year 2017-18, intercropping system achieved an equivalent yield of 8.6 q/ha compared to 7.1 q/ha of sole cropping. Similarly, in NICRA village D. Nagenahalli Groundnut + Pigeon pea - 8:2 has resulted in 18% higher yield compared to sole cropping. Improved varieties and resilient technologies resulted in enhancing income and minimized the impact of climatic variability (Table 2.2.5).

Table 2.2.5: Productivity of Groundnut + Pigeon pea (8:2) intercropping in Tumkuru district

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)
Groundnut +Pigeon pea BRG-2	15.3	18000	34500	16500
Groundnut	13.0	17600	26000	8100

Upscaling: Resilient intercropping system was adopted in areas of water scarcity and intermittent dry spells. Intercropping system has wider scope in area which experiences recurrent dry spells. It can be upscaled in the district through programmes of State Agricultural Department such as NFSM.

Groundnut + Pigeon pea (10:2) in Chikkaballapur district

Groundnut + Pigeon pea (8:2) in Tumkuru district

Profitable intercropping of Maize + Pigeon pea (6:1) for low rainfall regions of South Karnataka

Details of technology: Farmers in the NICRA villages of Davangere, Tumkuru and Gadag districts grow maize as sole crop during *kharif* season with local practices. Farmers were demonstrated with Maize + Pigeon pea (6:1) to increase the productivity and profitability. Intercropping with improved varieties resulted in higher yields. Cereal + Legume intercropping provides much scope for minimizing the adverse impact of moisture stress in addition to improving system productivity and soil health. The technology was taken up in various (Davangere, Tumkuru and Gadag districts) locations.

Performance and impact: In Siddanuru village, though good rainfall was received for sowing the crop, the crop suffered dry spells (>15 days) at vegetative stage (30-40 DAS) during the years 2011, 2012, 2015-18 in the month of July and August (25 days) and mid season (initiation of tassel and cob i.e 50-70 DAS). Long dry spells affect the productivity of Maize crop. There was a drastic reduction in the yield of the maize when grown as sole crop. Low rainfall at critical stages had reduced the yield of maize as a sole crop. Intercropping of Maize + Pigeon pea (6:1) was demonstrated which obtained a maize equivalent yield of 47.48 q/ha with yield improvement of 34%. The net income from intercropping systems were higher (Rs.13228/ha) compared to the sole crop (21.95 q/ha) (Maize). In Mahalingapur village, farmers attained an equivalent yield of 30.3 q/ha compared to 25 q/ha in sole cropping with net income of Rs.12600/ ha. The intercropping system earned higher profits by minimising the effect of moisture stress at vegetative stage (Table 2.2.6).

Table 2.2.6: Productivity obtained from Maize+Pigeon pea (6:1) intercropping system in stress year in NICRA villages

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Gadag				
Farmers' practice : (Maize as sole crop)	21.95	25628	26340	712
Maize+Pigeon pea (6:1) intercropping system (Maize equivalent yield)	36.96	32980	44355	11374
Davangere				
Farmers' practice : (Hybrid Maize as sole crop)	35.40	34500	38940	4440
Maize+Pigeon pea (6:1) intercropping system (Maize equivalent yield)	47.48	39000	52228	13228

Upscaling: Resilient intercropping system was adopted in 445 ha area (Davangere) in the village. Intercropping system has wider scope in regions which receive frequent dry spells, can be upscaled in the district through State Agricultural Department programmes such as NFSM.



Resilient intercropping system of Maize + Pigeon pea (6:1) in Davangere and Chikkaballapur districts

Drought tolerant foxtail millet cv DHFt-109-3 for low rainfall regions of Northern Karnataka

Details of technology: Millets are grown under extreme environmental conditions, where inadequate moisture and poor soil fertility is prevalent. Low rainfall situations prevailing in Belagavi and Gadag districts of Karnataka are suitable for growing foxtail millet. Farmers of NICRA villages grow local Halanavane which is susceptible to moisture stress and also a low yielding variety. Drought tolerant and high yielding variety DHFt-109-3 was demonstrated in farmers' field which can withstand the drought in early stages and also recover with subsequent rains.

Performance and impact: There was 30-60%deficit in rainfall in the years 2014-2018. The NICRA villages of Belagavi and Gadag districts experienced late onset of monsoon and 25-60 days dry spells especially in Gadag district. Grain yields of foxtail millet was higher by 28% with an yield of 4.6 q/ha during the drought year, whereas, during normal rainfall year the yield enhancement was 28% compared to local variety (Halanavane) (10.6 q/ha) with a net income of Rs.8600/ha. Resilience achieved was 44% due to the adoption of drought tolerant variety in the deficit rainfall year (Table 2.2.7).

Table 2.2.7: Impact of drought tolerant foxtail millet variety DHFt-109-3 in Belagavi district

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)
Farmers' practice: local Halanavane	3.6	7500	10440	2940
Improved variety: DHFt-109-3	4.6	8220	13340	5140

Upscaling: The variety can be upscaled to larger area in both districts in convergence with programmes such as NFSM. Recommended for cultivation under Southern Zone (Telangana, Andhra Pradesh & Karnataka).

Drought tolerant foxtail millet variety – DHFt-109-3 in NICRA villages of Gadag and Belagavi districts, Karnataka

Crop diversification of maize with medium duration blackgram variety DBGV-5 for low rainfall regions

Details of technology: Farmers of Yadagud village grow maize as traditional crop during *kharif* season. Maize crop experience stress under deficit rainfall conditions causing yield loss and low income. Introduced medium duration blackgram variety DBGV-5 in NICRA village. The drought escaping early maturing variety can tolerate moisture stress conditions compared to maize. The DBGV-5 variety is of 80-85 days duration with early harvesting and higher yield.

Performance and impact: In Yadagud village maize crop is generally sown during 2nd week of June and dry spell of more than 20 days occur during July month (Vegetative phase) resulting in crop failure and declining yields. In such situation, black gram crop was demonstrated to farmers. The variety recorded yield of 8.75 q/ha. Blackgram earned net returns Rs.30385/ha in the drought year. During normal year, the yield of blackgram is 13.54 q/ha with yield improvement of 18-25% compared to farmers' practice (Table 2.2.8).

Table 2.2.8: Impact of drought escaping black gram variety DBGV-5 in Yadagud village of Belagavi district

Intervention	Variety	Crop yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Farmers practice: Maize	Local	Crop failure			
Improved practice: Black gram	DBGV-5	8.75	17740	48125	30385

Upscaling: The yield from high yielding and medium duration variety encouraged farmers and was adopted in 48 ha benefiting 203 farmers during the year 2018. The water scarcity conditions in the village forced the farmers to cultivate blackgram instead of maize which cannot tolerate moisture stress conditions. The variety can be promoted as part of NFSM.

Medium duration blackgram variety DBGV-5 in Yadagud village of Belagavi district

Resilient intercropping system of Greengram + Pigeon pea (2:1) to cope early and mid-season drought in rainfed regions of North Karnataka

Details of technology: Sole crop of greengram in Mahalingapur village lead to low productivity due to long dry spells caused at early (flowering stage, i.e 25-35 DAS) and mid season (pod initiation and grain formation stage, i.e 45-60 DAS). To minimize the risk, Greengram (DGGV-2) + Pigeon pea (TS-3R) intercropping (2:1) system was demonstrated. Greengram with its rapid growth, cover the inter row space and conserve moisture and also hinders the weed growth. Legumes fixes atmospheric nitrogen in the soil and improve fertility of soil. This system provides farmers an insurance against failure of sole crops under prolonged dry spells.

Performance and impact: Mahalingapur village received deficit rain of 30-48% with 12-14 days and 20-25 days dry spells occurring during early and mid-season in greengram crop during the years 2018. Hence, it resulted in low income and less profitability to the farmers. Therefore, Greengram+ Pigeonpea intercropping system was demonstrated in NICRA village. Intercropping of Greengram + Pigeon pea (2:1) obtained a green gram equivalent yield of 7.9 q/ha with net income of Rs.10539/ha during stress year. Yield and net returns increase over sole cropping by 37.9% and 208%, respectively. The net income from intercropping systems were higher compared to the sole cropping. Yield resilience of 95% was achieved during the drought year compared to sole cropping (Table 2.2.9).

Table 2.2.9: Yield and economics of Greengram + Pigeon pea (2:1) intercropping system in Gadag district

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Stress year: 2018				
Farmers practice : (Greengram as sole crop)	5.7	24110	27527	3417
Greengram + Pigeon pea (2:1) intercropping system	7.9	27385	37924	10539
Normal year: 2019				
Farmers practice : (Greengram as sole crop)	8.3	29363	40820	11474
Greengram + Pigeon pea (2:1) intercropping system	12.2	39335	63187	23852

Upscaling: There was a significant adoption of intercropping system in an area of 25000 ha area in the district and can be further spread in convergence with NFSM.

Cultivation of Greengram + Pigeon pea intercropping (2:1) system in Mahalingapur village, Gadag district

Intercropping of Foxtailmillet + Pigeon pea (2:1) for stabilizing yields and income in drought prone regions of North Karnataka

Details of technology: Most of the farmers in Mahalingapur village are small and medium land holdings farmers. Their livelihood depends on farming. But the recurrent droughts lead to crop failures in the village, effecting the livelihood. Farmers follow traditional practices of growing susceptible varieties under sole cropping which severely affect the yields of crops. To overcome the situation, resilient intercropping system of Foxtail millet (DHFt-109-3) + Pigeon pea (TS-3R) intercropping (2:1) system was introduced to reduce the impact of early and mid-season droughts. This system provides farmers an insurance against failure of sole crops under prolonged dry spells. Intercropping benefits farmers with higher income during normal years and stable yields during stress years.

Performance and impact: Mahalingapur village received deficit rain of 30-48% with 12-14 and 20-25 days dry spells during early and mid-season in *kharif* season that resulted in low yield of crops. To overcome the stress conditions, demonstration of intercropping system with improved varieties Foxtail millet (DHFt-109-3) + Pigeon pea (TS-3R) was done to mitigate the early & mid-season droughts. Intercropping of Foxtail millet (DHFt-109-3) + Pigeon pea (TS-3R) obtained a fox tail millet equivalent yield of 13.7 q/ha with net income of Rs.11038/ ha compared to the sole cropping. Yield increase over farmers' practice is 67% during the drought year. Intercropping achieved resilience of 178% compared to sole cropping in the normal year which contributed significant impact on economics (Table 2.2.10).

Table 2.2.10: Impact of Foxtail Millet + Pigeon pea (2:1) intercropping system in Gadag district

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Drought year: 2018				
Farmers practice : Foxtail Millet as sole crop	8.2	11997	14760	2763
Foxtail Millet + Pigeon pea (2:1) intercropping system	13.7	13388	24695	11038
Normal year: 2019				
Farmers practice : Foxtail Millet as sole crop	7.7	18449	23094	4645
Foxtail Millet + Pigeon pea (2:1) intercropping system	17.9	34915	53753	18838

Upscaling: The adoption of intercropping systems have enhanced the income of the farmers as compared to sole crop cultivation even during drought years**.** The technology can be upscaled through programmes such as NFSM.

Foxtailmillet + Pigeon pea intercropping (2:1) system in Mahalingapur village, Gadag district of Karnataka

Location specific intercropping of Fingermillet + Pigeon pea (4:1) for sustainability in Tumkur district of Karnataka

Details of technology: D. Nagenahalli village is characterized with low rainfall, long dry spells in early season and high temperatures that affect the crop growth and yields. In order to overcome the adverse conditions, drought tolerant varieties with improved *in-situ* measures were demonstrated in village. Sole cropping in Fingermillet results in yield loss. To increase the sustainability of farmers, intercropping of Fingermillet + Pigeon pea (4:1) was introduced in the village. This system provides small farmers an assurance against failure of sole crops during long dry spells. The low productivity of local varieties can also be minimized from the improved varieties.

Performance and impact: D. Nagenahalli village experienced dry spells of 18-60 days during the years 2011, 2014, 2015, 2017 and 2018 in June, July and August months. Farmers cultivate sole cropping of finger millet, groundnut crop, which face the problem of moisture stress at various growth stages and obtain less yields. To stabilize yields and incomes of farmers, intercropping of Fingermillet + Pigeon pea (4:1) was introduced in the village. Intercropping of Fingermillet + Pigeon pea obtained higher finger millet equivalent yield of 5% compared to sole cropping in drought year. During the normal year intercropping yields were higher upto 26.2 q/ha. The improved varieties has resulted in higher yields and returns (Table 2.2.11).

Table 2.2.11: Yield and economics of Finger millet (ML365) + Pigeon pea (BRG2) (4:1) intercropping in Tumkuru district

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)
Stress year: 2018				
Farmers' practice: Sole cropping of finger millet	14.6	21650	37960	16310
Finger millet (ML365) + Pigeon pea (BRG2) (4:1)	15.2	21830	40720	18890
Normal rainfall year: 2019				
Farmers' practice: Sole cropping of finger millet	25.7	21502	57590	36448
Finger millet (ML365) + Pigeon pea (BRG2) (4:1)	26.2	21625	59900	38205

Upscaling: The practice can be further spread in convergence with NFSM.


Fingermillet + Pigeon pea intercropping (4:1) system in D. Nagenahalli village, Tumkur district of Karnataka

Short duration Horse gram var. PHG-9 as a contingency crop for weather abberations in South Karnataka

Details of technology: Semi-arid regions of Chikkaballapur and Davangere districts of Karnataka state receives rainfall of <700 mm. In NICRA Siddanuru village, most of the farmers keep land fallow after the harvest of maize. Only 5% grow horsegram and of low yielding varieties. To obtain higher yields and for cropping intensification, contingent crop of short duration PHG-9 horse gam was demonstrated to farmers. In S. Raguttahalli village, monsoon was delayed upto July 1st week delaying sowing of major crops during 2018. PHG-9 variety is high yielding with 100 days duration, semi spreading, semi-determinant growth habit, photo-thermo insensitive and tolerate high temperatures and moisture stress.

Performance and impact: S.Raguttahalli village, experienced delayed monsoon upto July 1st week during the years with long dry spells. Farmers were demonstrated horse gram as contingent crop with short duration variety PHG-9. Horse gram variety PHG-9 gave seed yield of 9.5 q/ha with net income of Rs.9900/ha and B:C ratio of 2.0. It resulted in yield improvement upto 19.5% compared to farmers' practice. It created assured income to farmers by reducing the risk of dry spells and moisture scarcity (Table 2.2.12).

Table 2.2.12: Yield of contingent horse gram variety PHG-9 in Davangere district

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Farmers practice : Local variety	2.8	10950	9800	1150
Contingent crop Horsegram variety PHG-9	5.3	12000	18550	6550

Upscaling: The variety can be further spread in convergence with developmental programmes such as NFSM and with the programme of ATMA.


Contingent crop of Horse gram variety PHG-9 in NICRA village of Chikkaballapur district

Contingent crop of Horse gram variety PHG-9 in NICRA village of Davangere district

Early maturing finger millet variety GPU-48 for escaping drought in South Karnataka

Details of technology: Farmers in Siddanuru (Davangere) and S. Raguttahalli (Chikkaballapur) villages grow long duration rainfed finger millet varieties which are susceptible to drought. Hence, short duration and drought escaping finger millet variety GPU-48 was introduced in *kharif* 2017 in the villages. The variety has a duration of 105-110 days with high grain and fodder yield. GPU-48 is an early maturing variety suitable for rainfed as well as irrigated areas and escapes terminal moisture stress. Moreover, the variety is resistant to blast disease.

Performance and impact: In Siddanuru village, in the year 2017 the onset of monsoon was 17^{th} July. It received 32.9mm rainfall in July and 83.7mm in August with dry spells at various stages of crop. To minimize the impact of low rainfall and dry spells, finger millet GPU-48 variety was demonstrated in NICRA villages. In Siddanuru village, cultivation of GPU-48 variety of finger millet showed increased yield of 22.50 % with fodder yield of 4 t/ha and resulted in net income of Rs.26300/ ha compared to local variety. In S. Raguttahalli village GPU-48 performed well under drought conditions with one protective irrigation at critical stage. It boosted the yield and mitigated the drought conditions. The productivity was 25% higher compared to local variety (Table 2.2.13).

Table 2.2.13: Impact of short duration finger millet variety GPU-48 in Chikkaballapur district

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Farmers' practice: local variety	15.5	21100	41300	19900
Improved variety: GPU-48	19.0	20200	48500	26300

Upscaling: The variety can be further spread in convergence with developmental programmes such as NFSM and with the programme of ATMA.


Finger millet variety GPU-48 in NICRA village, Davangere district of Karnataka

High yielding rabi sorghum variety SPV-2217 for Gadag district of North Karnataka

Details of technology: Mahalingapur village in Gadag district is a semi-arid region receiving normal rainfall of 615mm. Crops are cultivated under rainfed conditions during *kharif* and rabi crops are grown under residual soil moisture. Sorghum is the most important crop in *rabi*. Cultivation of M-35-1 variety of *rabi* Sorghum has resulted in low yields due to lodging and susceptibility to charcoal stem rot. Introduction of high yielding variety SPV-2217 in the village benefited farmers. SPV-2217 variety is suitable for early *rabi* sowing. It can be grown well under residual moisture conditions and can also tolerate moisture stress condition. The variety is resistant to Charcoal stem rot one of the major disease of sorghum.

Performance and impact: During the years 2015-18, there was a deficit of 30 to 40% rainfall with no rainy day in *rabi* season. To overcome the moisture stress in *rabi* crops high yielding drought tolerant sorghum variety SPV-2217 was introduced in village. The crop is sown with wider row spacing, attained higher grain yield upto 33% in the drought year of 2018. Additional net return of Rs.2222 was obtained compared to M-35-1 variety. The variety resulted in 28% higher yield and the income with improved variety SPV-2217, more than M-35-1 during the normal year (2019). The resilience achieved is 94% with the drought tolerant variety SPV-2217. Yield advantage of 94% is obtained in the drought year compared to local Maldandi variety during the normal year (Table 2.2.14).

Table 2.2.14: Performance of SPV-2217 sorghum variety in Gadag district

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Stress year: 2018				
Farmers' practice M-35-1 variety	4.5	14241	17443	3201
Improved variety: SPV-2217	6.0	15239	20663	5423
Normal year: 2019				
Farmers' practice M-35-1 variety	6.4	14547	17982	3472
Improved variety: SPV-2217	8.2	15485	23094	7640

Upscaling: The variety can be further spread in convergence with developmental programmes such as NFSM and with the programme of ATMA.



Rabi Sorghum variety SPV-2217 in NICRA village, Gadag district of Karnataka

Water saving aerobic rice variety MAS-26 in water scarce regions of Karnataka

Details of technology: Rice *(Oryza sativa L.)* is the most important cereal crop of India. In Karnataka, about 40-45% of the rice is grown under flooded conditions. Delayed monsoon, increases the water scarcity in drought prone regions delaying the rice transplanting thus reducing the yield. However, cultivation of aerobic method of rice cultivation was promoted replacing the traditional method. In D. Nagenahalli village aerobic rice method with drought tolerant rice variety MAS-26 was demonstrated. The drought tolerant aerobic rice MAS-26 is suitable for direct sowing avoiding puddling and transplanting and also resistance to pests and diseases. The aerobic rice method saves 50% water and 80% seed requirement.

Performance and impact: During the year 2018, there was a deficit of 35% rainfall. To overcome the water scarcity aerobic rice was demonstrated to farmers. The drought tolerant rice variety MAS-26 is suitable for aerobic rice cultivation. Shifting from traditional practices to new approach under the moisture scarce conditions benefited farmers in obtaining higher yields and productivity. Farmers growing aerobic rice with variety MAS-26 has achieved higher yield of 16% in the drought year (2018) compared to farmers' practice. In the normal year 2020, the drought tolerant variety MAS-26 has obtained higher yield of 22% along with lower water consumption compared to normal transplanting. The resilience achieved was 111% due to aerobic rice variety MAS-26 compared to farmers' practice (Table 2.2.15).

Table 2.2.15: Impact of Aerobic rice with variety MAS-26 in D. Nagenahalli village of Tumkuru district

Intervention	Grain yield (q/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)
Stress year: 2018			
Farmers' practice	28.7	25740	15875
Aerobic rice: MAS-26	33.2	25740	22400
Normal year: 2020			
Farmers' practice	29.9	24640	20674
Aerobic rice: MAS-26	36.6	25195	30209

Upscaling: The variety was adopted by 52 farmers in D. Nagenahalli village and can be further spread to large area in the district by integration with State developmental plans and NMSA.

Drought tolerant aerobic rice variety MAS-26 in NICRA village, Tumkur district

Drought escaping varieties of chickpea (JG-11& BGD-103) for Kalaburagi district

Details of technology: Chickpea is one of the major pulse crop of *rabi* season for drought prone regions of Karnataka. The productivity of the chickpea is less due to use of local seed and moisture stress conditions. To enhance the productivity, drought tolerant varieties, JG-11 and BGD-103 were demonstrated to farmers. JG-11 is a short duration of 95 days maturity and drought escaping variety which minimizes the yield loss.

Performance and impact: In NICRA village Melakunda, during the years, 2016 and 2018 *rabi* season received very low rainfall effecting the yields of other crops. The shallow to medium deep black soils is suitable for chickpea crop and it performed well under residual soil moisture conditions. The drought tolerant varieties of chickpea JG-11 and BGD-103 can withstand the moisture stress. Chickpea varieties of JG-11 and BGD-103 were demonstrated in 15 ha area in the NICRA village. During the stress year 2018, the variety performed better in moisture stress situations compared to local variety and achieved higher yield upto 12.6 q/ha. The yield obtained during normal year (2019) was 35.3% more over the local variety (Table 2.2.16).

Table 2.2.16: Impact of drought escaping chickpea varieties in Kalaburagi district

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs./ha)	Net income (Rs./ha)
Farmers' Practice: local variety	8.2	19000	30200
Improved variety: BGD-103	11.1	20000	48600
Farmers' Practice: local variety	10.3	16500	10280
Improved variety: JG-11	12.6	18000	14760

Upscaling: This variety is suitable for shallow to medium black soils of district. The farmers adopted the drought escaping varieties in the village and further adopted in adjoining villages. The climate resilient varieties (JG-11 and BGD-103) can be upscaled through Cluster Frontline Demonstration on Pulse Programme under NFSM.

Drought escaping chickpea varieties BGD-103 and JG-11 in NICRA village, Kalaburagi district

Short duration pigeonpea variety BRG-4 to minimise the impact of terminal drought in Tumkur district of Karnataka

Details of technology: Low and erratic rainfall coupled with frequent dry spells in NICRA village D. Nagenahalli of Tumkuru district impact crop growth and yields. Farmers, normally grow long duration pigeonpea varieties (150-160 days) such as BRG-2 which is released in 2009. The variety often experience moisture stress at the time of flowering and maturity resulting in low yields. To overcome the situation, new short duration variety BRG-4 (130-140 days) and high yielding, was introduced in NICRA village. The short duration variety BRG-4 is notified in the year 2014 by UAS, Bengaluru. The short duration BRG-4 is of indeterminate, mid early, suitable for normal and delayed sowings in rainfed regions. The high yielding variety can escape moisture stress at maturity and thus minimises yield loss.

Performance and impact: In the year 2018, D. Nagenahalli village of Tumkuru district received a deficit rainfall of 34% with less number of rainy days. Dry spells at vegetative growth stages effected the crop growth. Farmers were demonstrated with BRG-4 short duration and drought tolerant variety, which can minimise the impact of dry spells. Improved variety BRG-4 produced higher yield by 19% compared to old variety BRG-2 in the drought year (Table 2.2.17).

Table 2.2.17: Yield of short duration pigeonpea variety BRG-4 during drought year in Tumkuru district

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Tumkuru				
Farmers' practice : BRG-2	4.7	22,130	26,461	4,331
Improved variety: BRG-4	5.6	22,380	31,528	9,148

Upscaling: The improved variety can be upscaled to larger area in the Tumkuru district through CFLDs on pulses, State Agricultural Departmental programmes and Central schemes like NFSM.


Short duration pigeonpea variety BRG-4 in D. Nagenahalli village of Tumkur district

Dryland horticulture to stabilize income in frequently drought prone regions of Karnataka

Details of technology: Dryland ecosystems are vulnerable to water scarcity, drought and degradation which are impacting food security and livelihood. Dryland horticulture production systems in these lands help to mitigate the challenges, through provision of economic products, and by providing stabilized income under deficit rainfall siutations and other ecosystem services such as habitat for biodiversity, prevention of erosion, regulation of water, microclimate and improving soil fertility. In D. Nagenahalli village, rainfall is low and farmers received low income from the field crops. Introduction of fruit trees such as Jamun, Mango, Tamarind, Cashew and Amla, etc., were taken up in NICRA village of Tumkuru district. These fruit trees species has provided higher returns compared to annual crops during the years of drought. Similarly, in S. Raguttahalli village of Chikkaballapur demonstration of dryland horticulture was taken up.

Performance and impact: After the NICRA project, KVK staff has trained farmers and motivated towards growing of perennial fruit tree species. Many of them came forward to grow various fruit tree species in their lands (64.9 ha.) There was a significant increase in the area of adoption upto 204% in Tumkuru district, and 124% increase in Chikkaballapur district (Table 2.2.18).

Table 2.2.18 : Extent of adoption of dryland horticulture in NICRA villages

Horticulture crops	In D. Nagenahalli village (ha)	In S. Raguttahalli village (ha)
Mango	19.5	1.4
Tamarind	8.7	2.0
Aonla	4.4	-
Cashew	2.0	16.5
Jamun	0.5	3.1
Lemon	-	0.7

Farmers are earning sustained income from the fruit tree species. For instance, Amla planted during 2011 began giving yields from 2015. By selling of 1,700 kg Amla fruits, farmer has obtained net income of Rs.27900/ha @ 19/kg. About, 65 Tamarind trees planted during 2011 began fruiting during 2017. By selling 260 kg Tamarind, farmer gained a net income of Rs.23400 @ 90/kg. In S. Raguttahalli village, farmers obtained income of Rs.11890 by selling lemons and Rs.26500 by way of selling tamarind, whereas income from crop component was low due to drought.

Upscaling: Dryland horticulture can be upscaled as part of MIDH (Mission for Integrated Development of Horticulture)




Adoption of dryland horticulture systems in NICRA villages of Tumkuru and Chikkaballapur district

Short duration chickpea variety JAKI-9218 under moisture stress situations of Gadag district of Karnataka

Details of technology: In Gadag district, chickpea is the major *rabi* season crop. In NICRA village Mahalingapur, Gadag district of Karnataka in the year 2018, a drought year, no rainfall was received in *rabi* season. Farmers generally cultivate poor yielding varieties from farm saved seed of chickpea which are susceptible to drought. Short duration and drought escaping variety (JAKI-9218) was introduced in NICRA village which can complete the life cycle early and minimise the risk of moisture stress. It is a semi-spreading, with a duration of 112 days, profuse branching, light brown bold seeded, smooth surface, better quality and resistant to drought. Due to its quick growth and wide adaptability, the variety has become popular among the farmers' to overcome moisture stresses.

Performance and impact: The village received a *kharif* deficit rainfall of 46-67% during the years 2017 and 2018. Little rainfall is received during *rabi*. The local variety cannot withstand the stress conditions and incurred yield loss. To maximize the yield, short duration chickpea variety JAKI-9218 which is drought tolerant and efficiently use residual soil moisture, was demonstrated in farmers field. Farmers were benefited with higher yield upto 29% with net income of Rs.6563/ ha with additional income of Rs.3730/ha compared to farmers variety in drought year. During the normal rainfall year, 44% yield improvement was obtained compared to Annigeri-1 variety. The resilience achieved due to JAKI-9218 is 90% (Table 2.2.19).

Table 2.2.19 : Yield and returns obtained from short duration chickpea variety JAKI-9218 in Gadag district

Interventions	Yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs/ha)	Net return (Rs/ha)
Stress year: 2018				
Farmers' practice: local Annigeri-1 variety	4.25	15875	18708	2833
Chickpea cultivation (JAKI-9218)	5.50	17637	24200	6563
Normal rainfall year: 2019				
Farmers' practice: local Annigeri-1 variety	6.10	19123	25620	6497
Chickpea cultivation (JAKI-9218)	8.75	23900	36750	12850

Upscaling: This technology was initially adopted in an area of 4 ha and spread to an area of 55 ha in Mahalingapur village. Presently, farmers have adopted JAKI-9218 chickpea variety in larger area of 1159 ha during last 6 years in the NICRA cluster of villages. The technology can be upscaled as part of NFSM.

Short duration chickpea variety JAKI-9218 in Gadag district

Short duration finger millet varieties to cope with the climatic vulnerabilities in South Karnataka region

Details of technology: Finger millet is the main staple *kharif* crop in South Karnataka. A sizable area under finger millet is also cultivated with limited irrigation during *kharif*. Long duration varieties with higher productivity such as MR-1 and MR-6 are grown with irrigation facility by farmers. Whereas, under rainfed situations, sowings may be delayed upto end of August due to delayed monsoon. Productivity of long duration varieties goes down with delayed planting. Hence, short duration finger millet varieties Indaf-7 and ML-322 of about 100-110 days duration were demonstrated in D. Nagenahalli village of Tumkuru district. The varieties initially introduced in a sizable area in the NICRA village, spread to a large area in the district. These varieties are suitable for delayed onset of monsoon and can perform better under early withdrawl of monsoon conditions.

Performance and impact: D. Nagenahalli village experienced long dry spells in June-July during 2018. The sowings was delayed, impacting the yields of long duration varieties. Significantly, higher yields was achieved upto 14-22% compared to MR-1 variety. The short duration variety performed well under rainfed conditions. By providing critical irrigations the yields of short duration finger millet varieties Indaf-7 and ML-322 can be further enhanced (Table 2.2.20).

Table 2.2.20: Performance of short duration finger millet varieties during stress year in Tumkuru district

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Farmers' practice : MR-1	19.5	21830	39294	17464
Improved variety: Indaf-7	22.3	22430	47103	24673
Farmers' practice : Local variety	19.5	21830	39294	17464
Improved variety: ML-322	23.8	22450	49390	26940

Upscaling: The varieties can be spread as part of NFSM and also the ongoing programs of agricultural department and ATMA which aims at spread of improved varieties of food crops.

Short duration finger millet variety Indaf-7 and ML-322, in NICRA village of Tumkur district

Nipping in pigeonpea to increase yield in drought prone regions of Karnataka

Details of technology: Pigeonpea (*Cajanus cajan* (L.)) is the preferable crop of rainfed areas because of its well developed tap root system to extract moisture from deeper soil layers. The productivity of pigeonpea is low due to cultivation on marginal and sub marginal agricultural lands with poor management practices. In farmers' practice, pigeonpea crop grows taller and coupled with branching pattern results in interlocking effect, excessive flower drop and decreased pod set, which generally leads to yield loss. Therefore, in NICRA village S. Raguttahalli of Chikkaballapur district demonstrated the nipping technique in pigeonpea varieties BRG-1 and BRG-5 at 45 days after sowing (DAS), where, the terminal buds are usually removed to induce more auxiliary branches at lower levels thus resulting in trained canopy, which contributes to yield improvement.

Performance and impact: Nipping, would result in producing more number of branches compared to farmers' practice. In S. Raguttahalli village, farmers were demonstrated mechanical nipping in high yielding BRG-1 variety at 45DAS to exploit the full potential yield under moisture stressed conditions. The practice of nipping contributed to higher under moisture stress situations due to more lateral branches and BRG-1 produced higher yield upto 18% over without nipping. The nipping in BRG-5 variety has achieved yield increase to 15% over without nipping during normal rainfall year. Nipping at 45DAS resulted in horizontal spread of the plants which in turn resulted in higher yields by bearing more flowers and pods (Table 2.2.21).

Table 2.2.21: Impact of mechanical nipping in pigeonpea in Chikkaballapur district

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Farmers' practice : Without nipping	9.5	31650	51300	19650
Improved variety: Mechanical nipping in pigeonpea	11.2	32450	61600	29150

Upscaling: Though nipping enhances yields, it requires more labourers resulting in escalation in the cost of production. Therefore mechanical nipping can cut down the extra costs and increase the area of adoption. The Custom hiring centres (CHC), established as part of NICRA project, can make available the required machines at low cost which can further decrease the cost of cultivation.



Mechanical nipping in pigeonpea variety BRG-1 in Chikkaballapur district

Little millet variety DHLM-36-3 for frequently drought prone situations of Northern Karnataka

Details of technology: Karnataka has significant area which is drought prone. There is need for alternate crops which can tolerate drought and utilise resources efficiently such as millets. Due to continuous drought for two years (2017 and 2018) with a deficit of 47 and 67% rainfall during *kharif*, alternate crop such as little millet was introduced in NICRA village Mahalingapur of Gadag district, to ensure income security during drought situation in dryland condition as a climate resilient crop. Drought tolerant variety DHLM-36-3 of little millet is introduced in village replacing traditional White Saame variety which produce low yields.

Performance and impact: The NICRA village experienced deficit rainfall during 2017 and 2018, which led to shortage of moisture for growing the high input requirement crops. In the year (2017 and 2018) the village recorded 47-67% deficit rainfall. Yields of little millet are higher upto 27% compared to local White Saame variety. Farmers benefited with additional income of Rs. 4138/ha inspite of low and variable rainfall (Table 2.2.22).

Table 2.2.22: Yield and economics of drought tolerant little millet variety DHLM-36-3 in Gadag district

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Farmers' practice : White Saame	6.42	14547	17982	3472
Improved variety: DHLM-36-3	8.17	15485	23094	7610

Upscaling: The climate resilient crop, little millet was adopted in significant area by resource poor farmers in the NICRA village. The area can be further enhanced by integration with programmes of state departments and NFSM.



Drought tolerant little millet variety DHLM-36-3 in NICRA village of Gadag district

Millet based intercropping system for enhancing resilience in drought prone regions of Karnataka

Details of technology: To enhance resilience in frequently drought prone regions, sustainable farming practice of intercropping with drought tolerant crops is a feasible option to adapt to change, overcome constraints and enhance productivity. In Chikkaballapur district, intercropping of Kodomillet + Pigeon pea (10:2) was demonstrated to enhance productivity and tolerate the drought/dry spells. The drought tolerant crops has minimised risk with minimal use of resources.

Performance and impact: S. Raguttahalli village of Chikkaballapur district, during the year 2018, rainfall of 403 mm was received in 18 rainy days only, associated with large annual rainfall deficit of 74% rainfall and *kharif* season deficit of 42%. Farmers were demonstrated with Kodomillet + Pigeon pea (10:2) intercropping to mitigate the dry spells and moisture stress conditions. Intercropping of Kodomillet + Pigeon pea (10:2) obtained a Kodo millet equivalent yield of 24% higher with net income of Rs.4000/ ha compared to the sole cropping during the drought year. Whereas, in normal rainfall year, Kodomillet + Pigeon pea (10:2) performed well and achieved yield upto 12% higher equivalent yields over the sole cropping. Intercropping achieved resilience of 50% compared to sole cropping in the normal year (Table 2.2.23).

Table 2.2.23: Impact of Kodomillet + Pigeon pea (10:2) intercropping system in Chikkaballapur district

Intervention	Crop yield (q/ha) (Kodo millet equivalent yield)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Stress year: 2018				
Farmers' practice : Kodo Millet as sole crop	5.0	13500	12500	-1000
Kodomillet + Pigeon pea (10:2) intercropping system	6.2	13500	17500	4000
Normal year: 2019				
Farmers' practice : Kodo Millet as sole crop	12.5	22500	31250	8750
Kodomillet + Pigeon pea (10:2) intercropping system	13.9	22500	38420	15920

Upscaling: The technology can be upscaled through convergence with State Agricultural Department and ATMA and NFSM.

Kodomillet + Pigeon pea (10:2) intercropping system in Chikkaballapur district

Seed hardening with $CaCl_2$ to ensure optimum plant stand conditions in pigeonpea crop for semi-arid regions of Karnataka

Details of technology: Pigeonpea is major pulse crop grown in drought prone regions of Karnataka. The productivity of the pigeonpea is less due to use of traditional practices and farm saved seed. Since, pigeonpea crop is grown in marginal lands, proper agronomic practices can enhance the productivity in dry lands. One such practice is seed hardening with 2% $CaCl_2$ before sowing. Seed hardening is an effective approach that helps in enhancing germination percentage, improve the vigour of plant to withstand the moisture stress conditions. In Mahalingapur village of Gadag district, farmers are demonstrated seed hardening with $CaCl_2$ for pigeonpea crop to enhance germination and to ensure optimum plant stand, to face soil moisture scarcity and to achieve better yield under stressed conditions. Seed hardening ensures higher plant stand, can with stand the moisture stress during the initial stage of crop growth.

Performance and impact: Seed priming with calcium chloride @ 2% enhances germination percentage, improves the crop vigour and induce drought tolerance to the crop. Farmers of NICRA village in Gadag district were demonstrated seed hardening technique in pigeonpea. This has resulted in enhanced germination percentage upto 98% compared to 82% in farmers practice. Subsequently, plant height was increased to 188 cm compared to 170 cm in normal sowing. The number of fruiting branches also enhanced, bearing 25% more number of pods and seeds per plant, contributing to yield improvement upto 16.5% compared to direct sowing. Therefore, seed hardening with 2% $CaCl_2$ improves germination, plant stand, uniform seed set and maturity with higher yields.

Upscaling: Seed priming with $CaCl_2$ play a vital role in mitigating the adverse effects of drought stress, there by contributing to higher yield. More than 80-85% of farmers in NICRA village of Gadag district are adopting this technology.

Seed hardening technique with 2% $CaCl_2$ in pigeonpea crop in Gadag district

Drought tolerant sorghum variety GS-23 for frequently drought prone regions of Karnataka

Details of technology: In Melakunda (B) village of Kalaburagi district, farmers grow traditional Maldandi sorghum varieties which are low yielders. There is a significant yield loss under stress situation. To over-come the situation, drought tolerant sorghum variety, GS-23 was demonstrated in the village. The drought tolerant variety conditions and can enhance yields. The GS-23 variety suitable for *rabi* season and has a duration of 100-115 days can perform well with residual soil moisture. The variety is moderately tolerant to charcoal rot.

Performance and impact: During the years, 2015-19, in Melakunda (B) village of Kalaburagi, there was a deficit of 33-72% rainfall. The *rabi* rainfall was low. The drought tolerant variety GS-23 was demonstrated in the village. The variety can minimise the impact of moisture stress conditions and contribute to higher yields. The variety has achieved higher grain yield of 25% compared to local variety. The *in-situ* practices demonstrated in the village such as compartmental bunding has further enhanced the yields. An additional income of Rs.11400/ha was realised by farmers from drought tolerant variety GS-23 compared to local variety (Table 2.2.24).

Table 2.2.24: Yield obtained from drought tolerant GS-23 sorghum variety in Melakunda (B) village of Kalaburagi district

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Farmers' practice : M-35-1	13.5	9200	48600	39400
Improved variety: GS-23	16.9	10000	60840	50840

Upscaling: The drought tolerant GS-23 variety can be upscaled through ATMA, state departments and NFSM.

Drought tolerant GS-23 sorghum variety in Melakunda (B) village of Kalaburagi district

Short duration Dolichos variety HA-4 under delayed monsoon conditions of Davangere district of Karnataka

Details of technology: In Siddanuru village of Davangere district, traditionally farmers grow vegetables for higher income during *kharif* season. But due to delayed monsoon conditions and prolonged breaks in monsoon, vegetable crops face moisture stress conditions and resulting to low yields. Some times prolonged dry spells of >10 days such as during the year 2018 impacted the yields of vegetables. To minimise the impact of weather aberrations, short duration *dolichos* variety HA-4 was introduced in the village. HA-4 variety is of 90-100 days maturity and photo insensitive variety.

Performance and impact: In NICRA village Siddanuru, few farmers cultivate *dolichos* as vegetable crop besides other crops. But under delayed monsoon condition, long duration vegetable varieties are not suitable and incur loses due to prolonged dry spells and early withdrawal of monsoon. Under this circumstances, short duration and high yielding variety HA-4 was demonstrated to farmers. The short duration variety is suitable for late sowing conditions without impacting the yield. Due to its earliness, the variety can fetch better market price. The variety HA-4 has yield improvement upto 26% compared to local variety during the stress year. An additional return of Rs.6500/ha was obtained from short duration variety HA-4 than local variety (Table 2.2.25).

Table 2.2.25: Performance of short duration *Dolichos* HA-4 variety in Davangere district

Intervention	Crop yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Farmers' practice : Local variety	14.7	15080	28665	13585
Improved variety: HA-4	18.5	16000	36075	20075

Upscaling: The short duration HA-4 variety can be upscaled to larger area in the district by convergence with ATMA and state department programmes.

Short duration Dolichos HA-4 variety in Siddanuru village of Davangere district

Intercropping of Bajra + Pigeonpea (2:1) to obtain sustained income for drought prone regions of North Karnataka

Details of technology: Normally, farmers in Mahalingapur village of Gadag district grow bajra as a sole crop. The village experienced a deficit rainfall of 68% with annual rainfall of 120 mm with 10 rainy days during the *kharif* season. To enhance the productivity of farmers' instead of sole cropping with Bajra, KVK scientists introduced intercropping of Bajra + Pigeonpea (2:1) in the NICRA village. The improved and drought tolerant bajra variety ICTP-8203 and pigeonpea variety TS-3R has increased the yields of crops. Similarly, in Melkunda (B) village (Kalaburagi), farmers replaced the sole crop of Bajra with intercropping system which resulted in higher yields. The intercropping system has contributed to assured income by minimising the impact of drought.

Performance and impact: Mahalingapur village of Gadag district, received a deficit rain of 68% during *kharif*. Farmers of Mahalingapur and Melkunda (B) were demonstrated with Bajra + Pigeonpea (2:1) intercropping system with drought tolerant varieties ICTP-8203 (Bajra) and TS-3R (Pigeonpea). In both the locations intercropping of Bajra + Pigeonpea (2:1) obtained a Bajra equivalent yield of 40-50% higher with additional net income of Rs.16000-21000 / ha compared to the sole cropping during the drought year in both the districts. The intercropping has increased stabilized income during drought (2018) situations in the village (Table 2.2.26).

Table 2.2.26: Impact of Bajra + Pigeon pea (2:1) intercropping system in North Karnataka

Intervention	Crop yield (q/ha) (Bajra equivalent yield)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Kalaburagi				
Farmers' practice : Bajra as sole crop	12.5	31250	75000	43750
Bajra + Pigeonpea (2:1) intercropping system	17.5	40000	105000	65000
Gadag				
Farmers' practice : Bajra as sole crop	10.7	10725	21496	10771
Bajra + Pigeonpea (2:1) intercropping system	16.4	23467	51158	27691

Upscaling: The Bajra + Pigeonpea (2:1) intercropping technology can be upscaled through convergence with State Agricultural Department and ATMA.

Bajra + Pigeonpea (2:1) intercropping system in Mahalingapur village of Gadag district

2.3 Promising Climate Resilient Animal/Fisheries Technologies

Backyard poultry as a source of supplementary income to the farmers in low rainfall regions of Karnataka

Details of technology: In low rainfall regions of Karnataka especially in Chikkaballapur district, farmers are resource poor and are having small holdings. To provide a source of supplementary income, backyard poultry with Kadaknath and Grama Priya varieties were introduced in NICRA villages. S. Raguttahalli NICRA village of Chikkaballapur district experiences frequent droughts with higher ambient temperatures resulting in huge mortality in local chicks and substantially decreasing the income of farmers. Kadaknath is an ideal breed, rich in protein and can adapt to higher temperatures >38^{0}C. KVK introduced Kadaknath chicks to overcome this type of climatic stresses. Similarly, later Grama Priya a dual purpose variety with multi-colour plumage was introduced to provide higher income to the farmers. Similarly, in NICRA village Mahalingpur in Gadag district, Giriraja variety introduced.

Performance and Impact of technology: Kadaknath meat was nutritious with rich protein and low fat. The average age of egg laying was 140 days with egg production of 120 no. per bird per annum. Grama Priya starts laying eggs at an age of 175 days and lays 200 no. per bird per annum. About 40 and 80% higher body weight gain was observed in Kadaknath and Grama Priya birds respectively, compared to local birds in 6 months period. The net income raised to Rs.34000 per 50 birds of Kadaknath and Rs.32700 per 50 birds of Grama Priya compared to desi chicks (Rs.23500) if all the chicks survive (Table 2.3.1).

Table 2.3.1: Performance of chicks in enhancing income of farmers in Chikkaballapur district

Intervention	Body wt (kg/ 6 months)	Cost of rearing (Rs./ bird)	Gross return (Rs./ bird)	Net return (Rs./ bird)
Farmers' practice- local birds	1.0	405	690	470
Kadaknath	1.4	480	1160	680
Grama Priya	1.8	586	1240	654

Upscaling: Backyard poultry with Kadaknath and Grama Priya chicks offers great potential in providing supplementary income and additional employment to farmers. Consequently, farmers showed great interest in rearing birds of Grama Priya and Kadaknath and adopted by majority of the farmers in the village & nearby villages. Supply of chicks to the farmers was streamlined by integration with Directorate of Poultry Research, Hyderabad, self-help groups (SHGs), ATMA programme and contributing to sustainable livelihoods in rural areas.

Rearing Kadaknath and Grama Priya poultry chicks in NICRA village of Chikkaballapur district

Breed upgradation to enhance income from sheep rearing in drought prone districts of North Karnataka

Details of technology: Local non-descriptive sheep has low twinning, low litter size, resulting in lower income to farmers. Hence, NARI Suwarna sheep was introduced under NICRA in Chikkaballapur district to increase the twinning and litter size in sheep. The Nimbkar Agricultural Research Institute, Mumbai has developed the NARI Suwarna strain of Deccani sheep with the ability to produce and rear twin lambs. NARI Suwarna crossbred ewes have the ability to give twin lambs because of FecB gene. This breed is tall and larger than Deccani with faster growth. NARI Suwarna ewes are capable of producing milk for raising twin lambs to a weaning weight of 13-15 kg each in 3-4 months with little supplementary feeding. NARI Suwarna sheep increase flock size quickly due to twinning capacity with an average litter size of about 1.6 (i.e. 16 lambs per 10 NARI Suwarna ewes). The breed can be crossed with local sheep for more lambs.

Performance and impact: With the introduction of NARI Suwarna sheep in NICRA village, twining increased substantially in the flocks (37-51%) and resulted in higher income to the tune of 35-45%. This also increased flock size by 22% compared to the local breed flocks in a year. Within two years improved breed animals are increased to 94 number in the village and by selling of ram lambs earned an income of Rs.245000. This has provided an additional source of income to the farmers in drought prone districts of Karnataka. As good animal management practices were imparted to farmers, mortality observed was also zero in the improved breed flocks compared to local (Table 2.3.2).

Table 2.3.2: Economics of improved sheep breeds NARI Suwarna in Chikkaballapur district

Intervention	Year	No. of pairs	Before upgradation			No. of upgraded (October 2018)				Income generated from sale of rams
			Total	Male	Female	Total	Male	Female	Mortality	
NARI Suwarna	2016	12	24	10	14	52	28	24	0	115000
Local breed		12	24	10	14	38	22	16	2	85500
						No. of upgraded (December 2020)				
NARI Suwarna	2018	26	52	28	24	94	48	36	0	254000
Local breed		26	52	28	24	62	34	28	4	175000

Upscaling: The introduced breed sheep are well suited to semi-arid regions of Karnataka. In convergence with the animal husbandry department, Farmer's Producing Organization (FPOs) and with all the sheep rearing farmers in the village this activity could be spread in the district. However, streamlining the supply of feed supplements further lower the cost of production and enhance farmer's income in these perennially drought prone districts.

Breed upgradation with NARI Suwarna sheep in NICRA village of Chikkaballapur district

Hydroponic fodder production to sustain productivity in milch cows in low rainfall regions of Karnataka

Details of technology: Green fodder plays a significant role in milk production and reproductive performance of dairy animals especially high yielders. Non-availability of quality fodder round the year is major limitation for sustainable dairy farming. Fodder scarcity, majorly green fodder is continuously hampering the milk production in low rainfall regions. To overcome this problem, hydroponic fodder production as an alternative has been demonstrated in NICRA villages for better feeding of dairy animals. Hydroponic fodder production using low cost greenhouses was demonstrated with maize as it is the most commonly grown fodder under hydroponics.

Performance and Impact of technology: Low cost greenhouse which costs < Rs.1000 was demonstrated. The trays are placed at different levels. Clean and fresh seeds of maize (*Zea mays*) were soaked in tap water for 12h and kept for sprouting in air tight condition for 36h. The sprouted maize seed was spread in the trays @ 2.0 kg/3.75sft. The first trays were on the top row and change every day to the lower rows replacing with new trays. The seedlings were allowed to grow for 5 days and on sixth day, entire fodder along with root mat has been removed and fed to the dairy animals. In NICRA village Siddanuru of Davangere district, hydroponic fodder maize being fed to the cattle @ 1kg/day along with finger millet/maize straw during summer months for cross bred cows. The technology has increased the milk production upto 35% compared to feeding the cattle only with dry roughages. The fat content also improved by 5% resulting in better price to the produced milk. The staggered sowing of fodder maize was practiced so as to continuously produce and supply green fodder to the milch animals (Table 2.3.3).

Table 2.3.3: Impact of hydroponic fodder maize in NICRA village of Davangere district

Intervention	Milk yield (l / Day)	Cost of cultivation (Rs)	Net return (Rs)
Farmers' practice: sole dry roughage feeding	9.10	128	100
Supplementation of fodder maize along with roughages	10.66	130	137

Upscaling: The fodder shortage during summer in the scarce rainfall areas could be mitigated with hydroponic fodder production under low-cost, locally made greenhouses. The cost of concentrate feed can be reduced by supplementation of green fodder and this is more suitable for low rain fall areas to meet the green fodder demand of small and marginal farmers. By integration with the animal husbandry department, Farmer's Producing Organization (FPOs), this could be upscaled in drought prone districts for sustainable milk production and livelihoods in rural areas.

Establishment of hydroponic fodder maize in NICRA village of Davangere district

Composite fish culture in farm ponds with harvested water to enhance income of farmers in low rainfall regions

Details of technology: Water harvesting structures such as farm ponds and village tanks created under NICRA programme amplified the scope for fish farming. Traditionally farmers are growing local species which attain lower weight at catching resulting in less returns to the farmers. Hence, in NICRA village Melkunda of Kalaburagi district, composite fish farming with Catla, Rohu and Common carp (3:4:3 ratio) was introduced in harvested water. The farmers are provided with proper trainings on pisciculture in unutilized seasonal ponds for fish rearing and feed preparation using low cost feed material available locally such as Rice bran, Ground nut cake, cattle dung, lime. Time to time advisories on management practices and control of bacterial and viral diseases reduced the mortality and increased the fish yield and returns. Renovation of defunct village tanks under NICRA has fetched additional returns to the small farmers through pisciculture.

Performance and Impact of technology: Traditional yearlings gain low body weight and fetches low market price and returns. Introduction of composite fish farming (Catla, Rohu, Common carp) with scientific management in harvested water improved the yields and returns. The survival rate was 80% which gains body weight of 800 g and length of 24 cm for Catla, Rohu (600g and 20 cm), Common carp (400g and 14 cm) in 6 months time compared to farmers practice. Average net return of Rs.300000 was obtained from each farm pond compared to farmers' practice (Rs.125000). Farmers in S. Raguttahalli village (Chikkaballapur) has started farming with 400 fingerlings of Jayanthi Rohu in harvested water of farm pond and earned a net income of Rs.20100. After seeing these interventions, about 15 farmers came forward and were continuously rearing year after year the pisciculture with Jayanthi Rohu species and obtaining good subsidiary income besides sustainable intensification of crops with the harvested water in farm ponds (Table 2.3.4).

Table 2.3.4: Income obtained from composite fish farming in NICRA village of Kalaburagi district

Intervention	Total fish released	Cost of fish farming (Rs.)	Quantity of fish harvested (after 6 months) (kg)	Gross income (Rs.)	Net income (Rs.)
Farmers' practice	8553	35000	4000	160000 (Rs.40 / kg)	125000
Composite fish farming	13330	60000	6000	360000 (Rs.60 / kg)	300000

Upscaling: Since fish farming is fetching higher returns, farmers were very much interested towards this activity. Aquaculture in farm ponds and tanks are the best choice to increase the farmers income and productivity. Hence SAUs, NGOs along with fisheries department has lot of potential for short duration fish farming in farm ponds and village tanks by providing yearlings of good quality & some feed inputs and capacity building programmes.

Composite fish culture with fingerlings in NICRA village at Kalaburagi district

Cage system of poultry rearing to increase productivity in low rainfall regions of North Karnataka

Details of technology: Backyard poultry is a low input business practised in rural areas in the country. Traditional system of poultry keeping was done in open areas and where in chicks at early age are prone to predators. Therefore, to reduce the risk from the predators, KVK introduced cage system of rearing in Mahalingapur NICRA village at Gadag district. Cage system provide proper shelter to the birds during extreme weather conditions and protection from predators. This system involves rearing of poultry on raised wire netting floor in smaller compartments, called cages, either fitted with stands on floor of house. The droppings are either collected in trays underneath cages or on the floor.

Performance and Impact of technology: Demonstrated rearing of Grama Priya chicks under cage system in Mahalingapur NICRA village. The chicks were provided with regular feed and wholesome drinking water. Mortality is very low as they are free from diseases and or predators and weight gain is high due the supplemented feed. After 4-6 weeks, the chicks were allowed free range grazing at backyard and only during night time and at also laying eggs are allowed into the cages. The birds gained upto 82% more live weight in cage system compared to free ranging. The egg production also increased up to 34% with good quality of eggs. Birds of 12 weeks old weighed 1.5 – 2.5 kg. Though the cage cost is relatively high, the overall benefit (interms of higher survival and more weight gain & quality eggs) and net returns are higher (Table 2.3.5).

Table 2.3.5: Egg production and body weight gain of Grama Priya chicks in Gadag district

Intervention	Sale of eggs/unit	Sale of Cocks/unit	Body wt (kg/ 3 months)	Cost of rearing (Rs./unit)	Gross return (Rs./unit)	Net return (Rs./unit)
Farmers' practice-Free ranging	1058	4	1.2	6580	11856	5276
Cage system	1777	4	2.2	6100	13410	7310

Upscaling: Since cage system has an advantage of less floor space, more feed efficiency and protection from predators, it has spread successfully in the KVK villages. This can be scaled up through ATMA programme, SAUs, All India Coordinated Research Project on Poultry Breeding, Poultry Farm, Department of Animal Production by providing chicks at reasonable cost and incentives for cage culture.

Backyard poultry bird management under cage system at Gadag district

Supplementation of mineral and vitamin mixture to improve milk productivity in crossbred cows in semiarid regions of Karnataka

Details of technology: Availability of green fodder is the major constraint in drought prone regions making liable to various deficiencies in animals particularly cross bred cows. In dryland condition dairy animals mostly depend on dry fodder. Feeding of sole dry fodder during lean period leads to reduced intake of feed and fodder, low milk yield and reproductive problems in dairy animals. Sustenance of milk production requires supplementation of minerals and vitamins, the requirement is little high for high yielding animals. Furthermore, cross bred cows require more quantity compared to local cows. Most of the feed mixtures available for the livestock are deficient in one or another mineral. Hence, providing Area Specific Mineral Mixture (ASMM) with chelated minerals could mitigate mineral deficiency problems in dairy animals. Supplementation of mineral and vitamin mixture to crossbred cows was introduced in NICRA village of Davangere district to mitigate the deficiencies for improving the milk productivity. The chelated mineral and vitamin mixture comprises of all the essential vitamins, macro and micro minerals like Vitamin A, Vitamin D_3, Zinc, Magnesium, Manganese, Iron, Copper, Nicotinamide, Iodine, Vitamin E, DL-Methionine, Cobalt, Potassium, Sodium, Calcium, Phosphorus and Sulphur. This mixture was supplemented @ 40 g/day to the crossbred cows along with feed.

Performance and impact of technology: The supplementation of chelated mineral mixture enhanced conception rate and milk production in crossbred cows. Crossbred cows supplemented have been conceived with 1st time insemination. Milk production was enhanced by 18%. Though supplementation increased the feed cost by Rs.6390/cow, while net income was improved by Rs.16110/cow during three months period. Further it decreased the calving interval and increased the life time productivity of the animal. Similarly, in S.Raguttahalli of Chikaballapura district also demonstrated in Holstein Friesian and Red dane cows, supplementation @ 20g daily enhanced milk productivity upto 12%. In Mahalingpur village (Gadag) about 55 dairy farmers have adopted the area specific mineral mixture supplementation and resulted in 17% higher daily milk productivity (Table 2.3.6).

Table 2.3.6: Milk production and economic returns due to mineral mixture supplementation in Davangere, Karnataka

Intervention	Milk production (l/day/cow)	Gross returns (Rs/cow)	Net returns (Rs/cow)	% increase in milk yield
No mineral mixture supplementation	8.3	186	146	18
Area specific Mineral & Vitamin mixture @ 40g/cow/day	9.8	213	179	

Upscaling: Initially demonstrations were conducted with few farmers and after seeing the beneficial effect of supplementation of chelated mineral and vitamin mixture, about 100 dairy farmers in the Siddanur village came forward and adopted voluntarily by purchasing the mineral packets from the local market. Farmers are earning sustainable income during the lean period also with this technology and benefiting the milch animals and heifers. This can be further upscaled through the Karnataka Milk Federation (KMF), rural and animal husbandry department by providing the mineral mixtures on subsidy to all the dairy farmers.

Supplementation with chelated mineral and vitamin mixture in Siddanur village of Davangere district

Azolla meal as a protein supplement for enhancing milk productivity in fodder scarcity areas

Details of technology: In drought prone regions of Karnataka huge shortage is there for green fodder and farmers are unable to afford the cost of concentrates for feeding dairy animals leading to lower milk production. Though the availability and preservation of green fodder was enhanced during rainy season, it must be supplemented with proper protein diet to sustain the milk production. As the farmers are poor, low cost interventions like *azolla* particularly during the lean period can be better suited under drought conditions. *Azolla*, a free floating water fern, rapidly growing on water surface, contains around 25% crude protein and other essential minerals like iron, calcium, magnesium etc and appreciable quantities of Vitamin A and Vitamin B_{12}. *Azolla* meal as alternative feed supplement to concentrates has been demonstrated in dairy animals at various locations in Chikkaballapur and Kalaburagi districts under NICRA. In village S.Raguttahalli, *azolla* was grown under the shade in cement rings. A plastic sheet has been spread in the ring and properly secured. To initiate *azolla* growth, sieved fertile soil mixed with cow dung and water (or biogas slurry) was added as fertilizer and the pond was inoculated with fresh *azolla* culture (about 800 g for a 2 m² ring). The first crop was ready in 15-20 days. Currently, many farmers were producing *azolla* for their cattle particularly one farmer has built 16 rings who has adopted dairy as an enterprise and earning good returns.

Performance and Impact of technology: The milch animal supplemented with fresh *azolla* ration @200-1000g /daily depending on the milk production. Each ring produces 5-6 kg fresh *azolla* per day for four months during the lean period could meet the daily nutrient requirement of milch animals. In S.Raguttahalli village of Chikkaballapur district, milk production was enhanced in cross bred cows to the tune of 7.8%. Milk fat per cent was also improved by 0.5-1.0% compared to farmers' practice of normal feeding. The cost of establishment was Rs.800 /farmer. In the NICRA village of Mahalingpur (Gadag), most of the farmers established *azolla* units and obtaining 13.5% higher milk production compared to animals feeding without *azolla* protein (Table 2.3.7).

Table 2.3.7: Milk productivity due to *azolla* protein in Chikkaballapur, Karnataka

Intervention	Milch breed	Ration of *azolla*	Milk production (l/day/cow)		% increase in milk yield
			Farmers' practice	Intervention	
Azolla protein	HF	200g/daily	18.0	19.5	7.6-7.8
	Jersey	200g/daily	14.0	15.2	

Upscaling: Higher protein content along with the rapid multiplication rate makes *azolla* an unique feed supplement during lean period for milch animals under dryland conditions. Because of its easy cultivation, low cost and quick benefits, this technology is highly suitable to the small farmers. The animal husbandry department and Karnataka Milk Federation (KMF), could upscale the technology by encouraging the farmers providing suitable incentives for adoption.

Azolla unit established by farmer in NICRA village S. Raguttahalli, Chikkaballapur district

Green fodder production through Multi cut fodder Sorghum CoFS-29 for sustainable dairy production in medium rainfall areas

Details of technology: Traditionally farmers in NICRA village D. Nagenahalli growing local fodder jowar variety for green fodder production resulting in lower fodder yields and thus impacting the average milk productivity of the animal. The single cut local fodder sorghum varieties leading to the non-availability of fodder during summer and off season. Farmers are largely depending on the milk production from cows and buffaloes as a major livelihood option in the rural areas, availability of green fodder is very important for sustainable dairy farming. Hence, multicut cultivar of sorghum (CoFS-29) was demonstrated during *kharif*, which has ability to withstand drought conditions. Later, multi cut high yielding sorghum variety was demonstrated in various locations such as Davangere, Tumkur, Belgaum, Kalaburagi to meet the fodder scarcity in drought prone regions.

Performance and Impact of technology: Due to availability and feeding of the green fodder to dairy animals even during lean season, milk productivity had improved upto 17% per animal per day and protein content was also improved upto 8%. The first cutting of this cultivar can be done after 60 days and subsequent cuttings at 40 days intervals. The green fodder availability significantly increased the average daily milk collection in the village. The additional net income obtained from the green fodder was Rs.51455 /ha (Table 2.3.8 & 2.3.9).

Table 2.3.8: Milk yield due to multi cut high yielding sorghum variety CoFS-29 in Davangere

Intervention	Area (ha)	Fodder Yield (t/ha/annum)	Milk yield (liters/day)	Net return (Rs/day)
CoFS-29	10	122	11.6	210

Table 2.3.9: Impact of multi cut high yielding sorghum variety CoFS-29 in Tumkur

Intervention	Area (ha)	Fodder Yield (t/ha/annum)	Net return (Rs/ha)
Farmers' practice	5	59	8065
CoFS-29	5	288	59520

Upscaling: Initially, the fodder variety CoFS-29 was taken up in 10 ha area involving 100 farmers in Siddanuru village of Davangere district and Tumkur district, later farmers started growing fodder in about 121 ha and the technology had spread to the adjoining villages also. The adoption can be further spread in the district by water harvesting in the village and providing critical irrigation to increase the fodder yield. With integration with other institute/organisations such as FPOs, NGOs and Karnataka Milk Federation (KMF) this can be further scaled up by providing required inputs on subsidy.



The multicut fodder sorghum variety CoFS-29 adopted in NICRA villages of Tumkur and Davangere districts

Enrichment of dry fodder for sustainable milk yield from dairy animals during summer

Details of technology: In semi-arid regions of Karnataka, acute shortage of green fodder prevails especially during summer season. The livestock in the villages of Davangere district solely depend on the low-quality dry roughages (ragi and maize stovers) during summer season. The dry roughages are low in protein, minerals and vitamins and are less digestible when fed alone to the milch animals. Hence, enriching the dry roughages has been demonstrated in Siddanur village of Davangere district so as to increase the digestibility of nutrients in dry roughages and enrich the nutrients especially protenous. Enriching of dry fodder was done with 3-4 g Enzymex powder + 1 ml Brolyatone tonic + 10 g Urea mixed in 300 ml water and sprayed on dry roughages to improve the nutritive value. After chopping the straw, it will be spread uniformly on tarpaulin sheet and sprayed the water containing dissolved mixture uniformly over the straw layer by layer. Later, it is filled into air tight bag and left for 2-3 weeks depending on the outside temperature before use.

Performance and Impact of technology: Animals feed intake increased along with milk production as the enriched fodder provided better nutrition to the milch animals during summer. This resulted in 19% increase in milk production and the quality of the milk was also improved. Additionally, overall animal health condition and reproduction also improved. This practice resulted in reduction in calving interval and repeat breeding problem in milch animals (Table 2.3.10).

Table 2.3.10: Enhancement of milk yield due to enrichment of dry fodder in Davangere, Karnataka

Technology	Milk yield (l / Day)	Fat and SNF content	Gross Cost (Rs/cow)	Gross return (Rs/cow)	Net return (Rs/cow)	Wastage of dry fodder (%)	Dry fodder digestibility (%)
Farmers' practice	7.6	SNF (8.0 – 8.3) & Fat (2.8- 3.2)	120	190	70	40-50	40-45
Enrichment of dry roughages	9.3	SNF (8.6 – 8.8) & Fat (3.8 – 4.2)	130	234	113	<5	>85

Upscaling: Nearly 1000 to 1200 tons of dry roughages per annum being enriched and about 78 farmers in the village have adopted this technology at Siddanur Village and can be further upscaled in the district especially in frequently drought prone regions of Karnataka in convergence with state animal husbandry department.

Enrichment of dry roughages in NICRA village Siddanur, Davangere district

Preservation of green fodder as silage during lean period in frequently drought prone regions of North Karnataka

Details of technology: Northern Karnataka region faces very severe moisture stress conditions inhibiting the growth of field crops and fodder crops. The situation is very severe during drought period where shortage of fodder occurs particularly during summer. In the NICRA villages Mahalingpur (Gadag) and Yadagud (Belgaum) preservation of green fodder as silage using polythene bags has been demonstrated. Though farmers having limited irrigation facilities, encouraged to grow maize in small area so that the fodder can be used for silage making. Further, surplus green fodder available during *kharif* was also preserved as silage using silage bags to mitigate the fodder scarcity. This low cost silage making benefited a lot to small farmers in enhancing the milk productivity of dairy animals during lean season.

Performance and impact: Being a low cost technology farmers showed keen interest in preparing silage for off season usage. Silage making ensured availability of green fodder during summer and lean periods. Silage feeding has increased the milk production and, on an average, milk has increased by 0.5-1.0 l/day in milch animals. Feeding silage also increased fat percent by 2.82% and milk production by 11.06%. More than 75% of the farmers adopted the silage making technology in the NICRA villages (Table 2.3.11).

Table 2.3.11: Milk production and economic returns due to Silage making in Gadag district

Intervention	Milk production (l/day/cow)	Gross returns (Rs/cow/60 days)	Net returns (Rs/cow/60 days)
Farmers' practice	8.15	19560	16560
Silage making	9.01	21624	18124

In NICRA village Melkunda (Kalaburagi), also demonstrated silage making which resulted in reduction in loss of hay by 20% and nutrient loss by 10% by effectively maintaining the green fodder in fresh state with good palatability.

Upscaling: On an average of 4-5 tons of silage being prepared by each farmer in the village. The technology can be upscaled by promoting through ATMA and State Animal Husbandry Departments providing required incentives to farmers. NGOs and milk cooperative societies could also take-up this to sustain the milk production during lean period by supplying silage bags.

Silage making in NICRA villages of Gadag and Belgaum districts

Urea Mineral molasses lick blocks as supplemental feed to increase productivity in lactating animals in semi-arid regions of Karnataka

Details of technology: In semi-arid regions, during December to May, water is the major constraint limiting the green fodder cultivation and subsequent availability leading to deficiencies in livestock in drought prone regions. Farmers are unable to provide concentrate feed due to its higher cost. Dairy animals need balanced ration containing sufficient quantity of concentrates, minerals, salts and vitamins to sustain the milk production and also mitigate the reproductive problems. The quantity of requirement of balanced feed increases with corresponding increase in milk production and the crossbred cows require more quantity compared to the local cows. Demonstrated UMMB as supplement feed to lactating cows and buffaloes in Melkunda village of Kalaburagi district inorder to meet the nutrient requirement of animals during lean period.

Performance and Impact of Technology: Supplementing animal with UMMB would provide adequate quantity of nutrients, efficient microbial protein production and improved digestibility. UMMB supplementation @ 1kg to each cow has enhanced on an average milk production by 9-11 per cent, fat content by 6-9% and repeat breeding problem also substantially reduced. UMMB supplementation has also reduced the skin diseases in cows and also incidence of Anoestrus was minimised (Table 2.3.12).

Table 2.3.12: Milk production and economic returns due to UMMB in Kalaburagi district

Parameters	Cows	
	Without supplementation	UMMB
Milk yield (Lts/Animal/day)	7.7	9.9
Total milk yield (Lts/month)	231	297
Net return (Rs.)	3775	5425
B: C ratio	2.8	3.7

Upscaling: About 80 dairy farmers in Melkunda village have adopted the technology. Farmers were also benefited in saving the costs against the skin diseases along with benefit of timely conception and enhanced milk production in lactating animals. After seeing the benefits of UMMB supplementation, farmers started voluntarily purchasing from local market. This can be promoted widely through the rural and animal husbandry department, dairy farmers FPOs, milk cooperatives by supplying UMMB on subsidy.



UMMB lick blocks supplement feed to cows in Kalaburagi district

Mitigation of fodder security by perennial fodder cultivation in low to medium rainfall regions of Karnataka

Details of technology: In low to medium rainfall districts such as Chikkaballapur, Belagavi, Kalaburagi, Davangere districts average milk productivity was very low in the NICRA villages due to the non-availability of green fodder during summer and off season. Farmers are largely depending on the milk production from local and cross bred cows and buffalos as a source of supplementary income. Though traditionally farmers in the NICRA villages are cultivating local fodder jowar variety for the green fodder purpose, the green fodder yields are very low and unable to meet the requirement of the dairy animals. Hence, improved cultivars of multicut sorghum (CoFS-29), maize (African Tall) during *kharif*, lucerne (RL-88) during *rabi* and perennial Hybrid napier (DHN-10), marvel grass. signal grass in irrigated lands were introduced. The water harvesting structures created in the village in large scale has further contributed to the spread of multicut perennial fodder crops.

Performance and Impact of technology: This resulted in year round continuous availability of the green fodder to lactating animals, milk productivity enhancement upto one litre per animal per day. Similarly, in small ruminants feeding with *Melia dubia,*and fresh and stored hay improved the body weight gain. In NICRA village Yadagud (Belagavi), feeding the animals with Lucerne had improved the milk productivity by 7-10%. The fodder yield of CoFS-29 in the village increased significantly upto 18%. Increase in availability of green fodder also resulted in reduction in calving interval, healthy calves and no anestrus and repeat breeding problems in milch animals. Further, milk collection at the co-operative centres increased by 17% during lean season and 23% during normal season. In NICRA village Melkunda (Kalaburagi), feeding of *Melia dubia* leaves to goats in the off season improved the body weight upto 15-18%.

Upscaling: This technology is suitable for areas in the district where harvested water is available for *rabi* crop. Initially, 25 farmers in Yadagud village started growing perennial Lucerne fodder in their small holdings after seeing the impact of the intervention. Farmers are getting additional income of Rs.5000-7000 from milk in the off season due to availability of green fodder. It has spread to other farmers in the adjoining villages and can be further upscaled on a large area through Karnataka Milk Federation, SAUs, Animal husbandry department through supply of lucerne seed/ planting slips of fodder grasses and saplings of *Melia dubia* to the needy farmers in the districts.



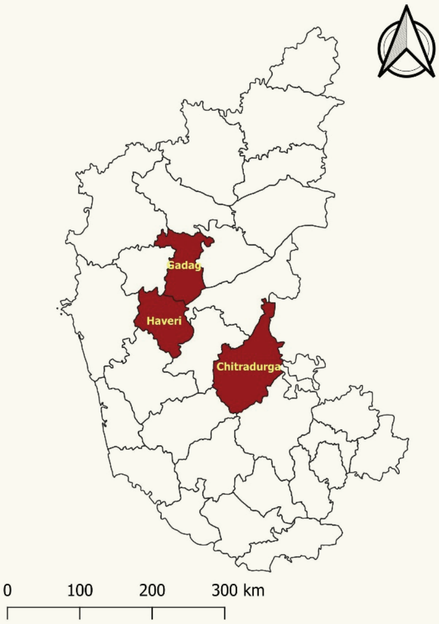
Growing of Perennial grasses in NICRA villages of Davangere and Kalaburagi districts

Resilient Technologies for risk prone districts of Karnataka and Approaches for Upscaling promising Climate Resilient Technologies

Resilient technologies for risk prone districts in Karnataka

Districts of Karnataka can be broadly categorized into very high risk, high risk, medium risk and low risk based on proneness to climatic change and variability (Ramarao *et al.,* 2019). Based on the on-farm experimentation being taken up as part of Technology Demonstration Component of NICRA and also other studies, technologies which can impart resilience to climate change and variability for various risk prone districts of Karnataka are indicated. The specific technologies for each of the farming situation in these districts depend on the predominant production systems, resource endowments and the production objectives of the farmer. Promising resilient technologies for each of the risk prone districts of Karnataka are as follows.

Promising resilient technologies for very high risk prone districts in Karnataka



Very high risk prone districts

Chitradurga, Gadag and Haveri

- Enhancing water storage by constructing farm ponds, community ponds, nala bunds and check dams to provide critical irrigation to rainfed crops
- Percolation ponds to augment ground water recharge of open and bore wells with filter unit and efficient use of harvested water for critical irrigation and cropping intensification wherever possible
- Construction of farm bunds to conserve soil moisture and to minimise erosion
- Tank silt application for enhancing soil moisture storage and soil fertility
- Efficient use of harvested water to high value crops such as small onion and jasmine
- Green manuring to enhance the soil fertility

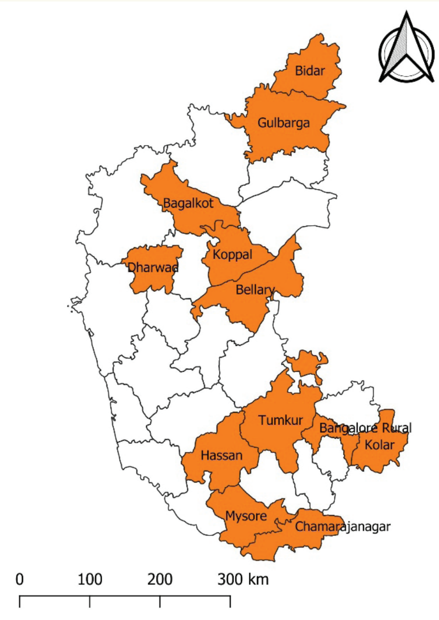
- Short duration and drought escaping varieties of green gram (DGGV-2) and foxtail millet (DHFT-109-3) for delayed onset of monsoon

- Drought tolerant variety of sorghum for minimising the impact of drought
- Short duration and drought tolerant chickpea variety (JAKI-9218) for moisture stress situations
- Intercropping systems of green gram + pigeonpea (2:1) and maize + pigeonpea (6:1) to minimise risk
- Improved fodder sorghum (CoFS-29) variety for milch animals to enhance the milk yield during lean season
- Silage making to make fodder available for livestock during the lean season
- Enrichment of dry fodder with minerals to overcome the mineral deficiency in lactating animals
- Feeding minerals and vitamins to milch cows to enhance the milk yield during lean season
- Cage system of poultry rearing with Grama Priya birds to increase income of farmers in low rainfall regions
- Azolla feed as protein supplement to increase milk yield
- Backyard poultry with Giriraja breed for stabilising income to farmers

Promising resilient technologies for high risk prone districts in Karnataka

High risk prone districts in Karnataka

Bagalkot, Bangalore rural, Bellary, Bidar, Chamarajanagar, Dharwad, Gulbarga, Hassan, Kolar, Koppal, Mysore, Tumkuru

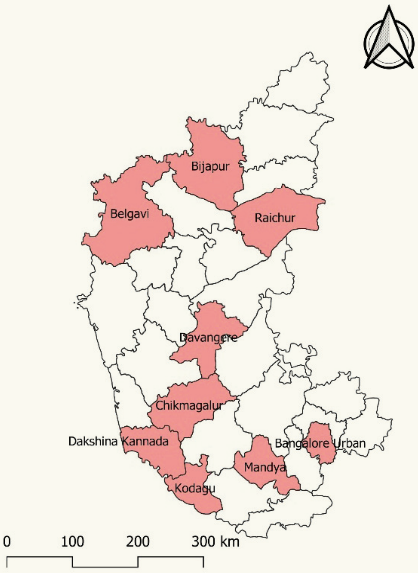


- Renovation/construction of water harvesting structures such as farm ponds, community ponds, and check dams to provide critical irrigation during dry spells for *kharif* crops and pre sowing irrigation for *rabi* crops
- Desilting of drainage channel to harvest more water for critical irrigation during prolonged dry spells/ drought
- Ground water recharge by establishing filter units to bore and open wells to enhance ground water level and efficient use of water for life saving irrigation to crops
- Soil test based nutrient application to rationalize fertilizer application and to increase crop yield
- Farm bunding for in-situ conservation and minimising erosion
- Trench cum bunding in groundnut for in-situ conservation and minimising the impact of dry spell/ drought
- Tank silt application for enhancing moisture holding capacity and improving crop yields
- Ridges and furrow planting of pigeonpea to conserve moisture and to minimize the impact of dry spells
- Efficient use of harvested water for crops like chrysanthemum, vegetables to enhance the water productivity and income in frequently drought prone regions
- Medium duration and drought tolerant finger millet (ML-365) variety for delayed onset of monsoon conditions

- ✦ Short duration pigeon pea variety (BRG 4) and medium duration BRG-1, BRG-2 and BRG-5 varieties for minimising the impact of drought
- ✦ Water saving aerobic paddy (MAS-26) to enhance productivity with limited water
- ✦ Crop diversification from maize to low input use crops like green gram and black gram for improving soil fertility and to obtain assured yields under drought situations
- ✦ Short duration foxtail millet variety DHFT-1093 for variable rainfall and drought

- ✦ Short duration finger millet varieties Indaf-7 and ML-322 for frequently drought prone regions
- ✦ Perennial tree crops such as *Melia dubia,* Amla, Tamarind, Jamun, Drum stick, Mango, Lemon for minimizing risk in frequently drought prone regions
- ✦ Growing horse gram (PHG-9) after harvest of maize for cropping intensification
- ✦ Resilient intercropping systems of groundnut + pigeon pea (10:2), finger millet + pigeon pea (10:2), finger millet + pigeon pea (4:1), kodo millet + pigeon pea (10:2), maize + pigeon pea (6:1) for stabilising income in drought situations
- ✦ Seed hardening with 2% $CaCl_2$ in pigeonpea for higher germination percentage
- ✦ Mechanical nipping in pigeonpea after 45DAS to boost the yields
- ✦ Enhancing green fodder production of sorghum by CoFS-29 for milch animals to enhance the milk production
- ✦ Silage making to preserve the fodder for off season and to increase the milk production
- ✦ Enriching the dry fodder (ragi and maize stovers) with vitamins and minerals to provide adequate nutrients to animals to enhance the productivity
- ✦ Feeding chelated minerals and vitamins mixture to lactating crossbred cows during December to May increases the milk yield
- □ UMMB lick blocks for animals to supplement deficient nutrient and to augment the milk yield

Promising resilient technologies for medium risk prone districts in Karnataka



Medium risk prone districts in Karnataka

Bangalore Urban, Belagavi, Bijapur, Chikmagalur, Dakshina Kannada, Davangere, Kodagu, Mandya and Raichur

- Water harvesting by construction of farm ponds, check dams and community ponds to provide critical irrigation to crops and their effective use for growing high value crops
- Percolation ponds for groundwater recharge with filter units and efficient use for irrigating cash crops
- Trench cum bunds in maize to conserve soil moisture and to minimise the impact of drought
- Dead furrows in maize crop to increase soil moisture and to minimise the impact of dry spells
- Micro irrigation system in flowers and vegetables from harvested water to enhance the water productivity and income
- Soil health cards for rational fertilizer application
- Drought escaping and medium duration pigeon pea BRG-5, BRG-2, BRG-1 varieties in frequently drought prone regions
- Drought tolerant finger millet variety ML-365 for minimise the impact of dry spells
- Contingency crop horse gram PHG-9 after the harvest of maize
- Resilient intercropping system of maize + pigeon pea (6:1) to minimise the risk and increase productivity
- Feeding *azolla* protein to animals during off season for enhancing productivity
- Green fodder production of sorghum (CoFS-29) and leguminous fodder(Hedge Lucerne) for milch animals to enhance the milk yield
- Enrichment of dry fodder with urea and minerals and enzymes mixture (ragi and maize stovers) for livestock
- Green fodder production through hydroponics to augment fodder production for landless
- Improved fodder storage by silage to make green fodder available for longer duration and to increase milk yield
- Supplementing minerals and vitamins to lactating cows during summer
- Backyard poultry with Giriraja, Kadaknath breeds for stabilising income to farmers

Promising resilient technologies for low risk prone districts in Karnataka

Low risk prone districts in Karnataka

Shimoga, Udupi and

Uttara Kannada

- Construction of Vijay bandhara for rain water harvesting and providing supplemental irrigation to paddy, and to high value crops
- Cropping intensification with harvested water
- Contour bunding in maize to conserve soil and to reduce erosion
- Water saving rice cultivation methods like direct seeded rice (DSR), system of rice intensification (SRI) to increase productivity
- Lodging tolerant paddy Swarna sub-1 to minimise the yield loss
- Green fodder production through improved cultivars for milch animals to enhance milk yield
- Silage making to make fodder available for longer duration
- Feeding minerals and vitamins for lactating cows for enhancing productivity and reproductive performance

Upscaling promising climate resilient technologies

As part of the TDC of NICRA, several resilient practices were found to be promising, which can minimize the impact of climate change and variability. Participatory demonstrations lead to identification of several technologies for 151 districts of the country which can effectively minimize the impacts of climate change and variability. Scaling out or scaling up of such options and technologies is the need of the hour to minimize the adverse impacts of climate change.

The resilient practices identified as promising as part of the TDC of NICRA can be integrated in to the ongoing developmental programmes of the country. Several programs, such as National Mission on Sustainable Agriculture, Mahatma Gandhi National Rural Employment Guarantee Programme, watershed Development Programme, etc. are operational in several districts of the country. Some of the resilient practices are integral components in it and several location specific resilient technologies are to be integrated in to it so as to reach large number of farmers. Some of the developmental programs are operational in selected locations and there is a need for further spread of these programs which have the components of the resilient practices.

Some of the natural resource management technologies requires high initial investment to minimise the adverse impacts of climate change. As the programs are being piloted by various departments with different guidelines, implementation mechanisms, there is a need for convergence of these programs at the village level, so that the farmers can take benefit of these programs depending on their resource endowments, farming situations. The proven practices are to be targeted depending on the bio physical environments, prevailing production systems and the specific vulnerabilities associated.

Resilient practices such as drought tolerant varieties of crops, intercropping systems, planting material of improved fodder crops, etc. can be upscaled by building capacities of communities and development of enabling mechanisms locally. Development of institutional frameworks locally can play a significant role in the adoption and spread of practices. Such mechanisms are to be created and nurtured by way of policy for the spread of climate resilient technologies.

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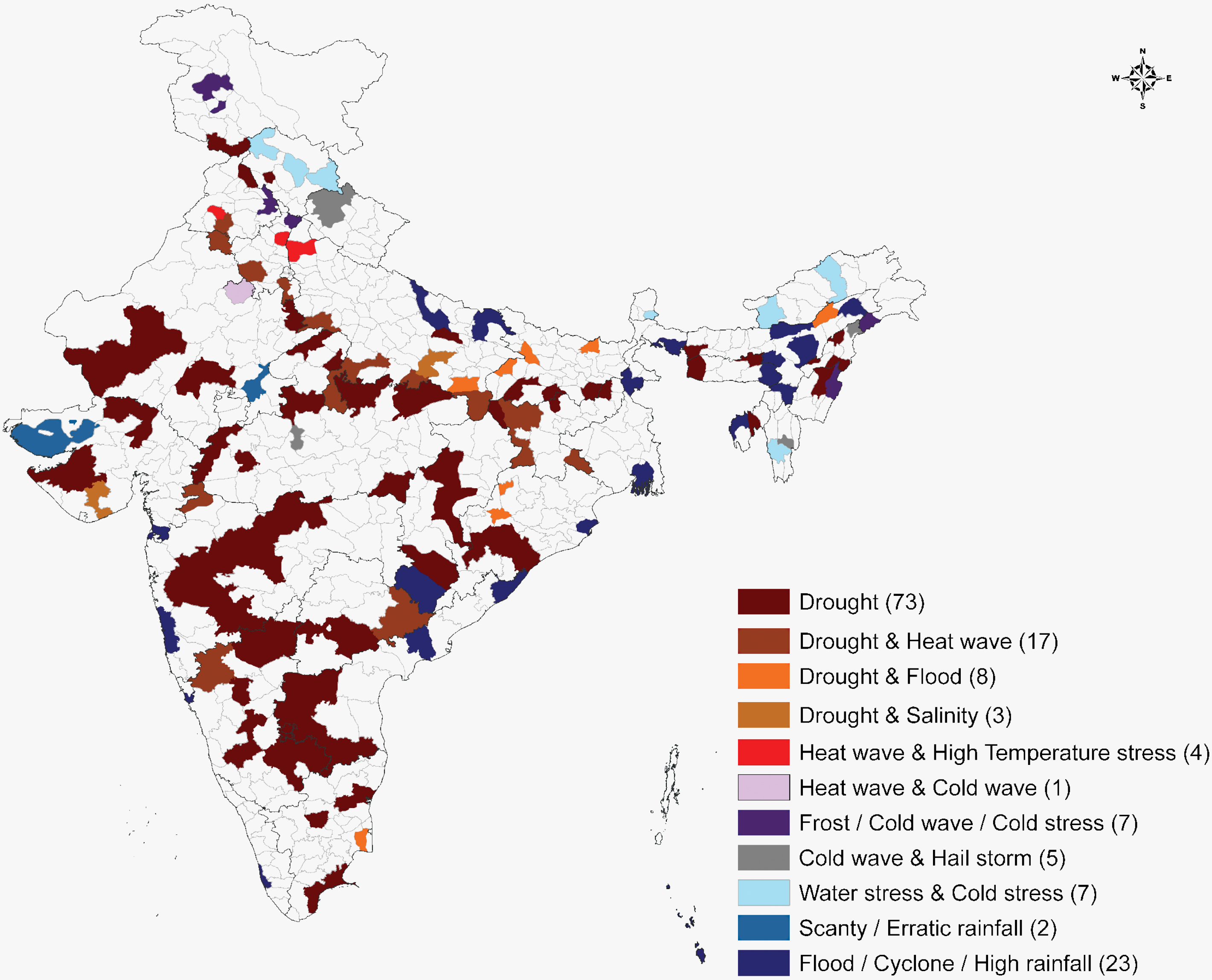

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