Climate Smart Agriculture and Advisory Services: Approaches and Implications for Future

Discussion Paper 1

MANAGE- Centre for Agricultural Extension Innovations, Reforms, and Agripreneurship (CAEIRA)

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About the Publication

The research report is based on the research conducted by Ms. Rupan Raghuvanshi as MANAGE Intern under the MANAGE Internship Programme for Post Graduate students of Extension Education during April-June, 2017.

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Director General's Message

Smt. V. Usha Rani, IAS
Director General, MANAGE

I congratulate Ms. Rupan Raghuvanshi, MANAGE intern and Ph.D. Scholar, G.B. Pant University of Agriculture and Technology, Pantnagar, for selecting relevant topic of the day "Climate Smart Agriculture Advisory Services: Approaches and Implications for Future" and collecting good data from field and analysis.

The paper in detail analyses the impact of climate change on Agriculture across the world in general and in India in particular. It is a well known fact that climate is changing rapidly and radically impacting poor and marginal farmers. Due to climate change, the sustainability of livelihoods of farmers especially in dry regions of this country as well as in coastal areas is at stake. The climate change is equally affecting agriculture and allied sectors. The need of hour is to gear up Research and Extension system empowering farmer to face the challenges posed by inevitable change of climate.

Various organizations including international have been implementing number of projects like "National Innovations on Climate Resilient Agriculture", (NICRA) by ICAR; "Climate Change Knowledge Network in Indian Agriculture" (CCKN-IA) by GIZ; Climate Change Adaptation (CCA), by WoTR. The impact and methods in these projects are discussed very elaborately. The paper analyses strengths and weaknesses of each of methods adapted in these projects.

The paper also discusses effectiveness of the extension strategies adapted in each of these projects including use of ICT for transmitting relevant information on weather and other advices to farmers. The paper is very much useful to the policy makers and field level officers to understand effective ways of transfer of knowledge to the doorstep of farmers enabling farmer to face the challenges posed by Climate Change.

The paper awakens Policy makers as well as field extension personnel the need for: (1) planning at block level; (2) quick transmitting weather information; (3) providing relevant advices to farmers through ICT; and (4) preparing farmers to face adversities of nature.

Let me congratulate Dr. Saravanan Raj, Director (Agri. Extn.), MANAGE and Dr. Suchiradipta Bhattacharjee, MANAGE Fellow (CAEIR) for guiding the intern in selecting right topics, applying right research methodology to collect relevant information, analyzing and suggesting appropriate way to move forward. Unless we are geared up, we are sure to receive shocks from fast changing climate in our country.

04.01.2018

(V.Usha Rani)

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Abbreviations

AGRIMATE	Automated Crop Weather Calendar Software
AIS	Agricultural Innovation Systems
ATMA	Agricultural Technology Management Agency
CBDM	Community Based Disaster Management
CCA	Climate Change Adaptation
CCAFS	Climate Change Agriculture and Food Security
CCKN IA	Climate Change Knowledge Network in Indian Agriculture
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Centre
CSA	Climate Smart Agriculture
CSV	Climate Smart Village
DRR	Disaster Risk Reduction
F2FE	Farmers to Farmer Extension
FAO	Food and Agricultural Organisation
FFS	Farmers Field School
FGD	Focussed Group Discussion
FIGs	Farmers Interest Groups
GACSA	Global Alliance for Climate Smart Agriculture
GDP	Gross Domestic Product
GFRAS	Global Forum for Rural Advisory Services
GHGs	Green House Gases
GIS	Geographic Information System
GIZ	German development cooperation
GOI	Government of India
ITC	Indian Tobacco Company
ICAR	Indian Council of Agriucltural Research
ICT	Information and Communication Technology
IFPRI	International Food Policy Research Institute
IMD	Indian Meteorological Department

IPCC	Intergovernmental Panel on Climate Change
IPPM	Integrated Plant and Pest Management
ITK	Indigenous Technical Knowledge
MANAGE	National Institute of Agricultural Extension Management
MICCA	Mitigation of Climate Change in Agriculture
NABARD	National Bank for Agriculture and Rural Development
NGO	Non Government Organisation
NICE	Network for Information on Climate (Ex)Change
NICRA	National Innovations on Climate Resilient Agriculture
PAS	Public Addressing System
PPS	Probability Proportional to Size
RAS	Rural Advisory Services
SAPCC	State Action Plan on Climate Change
SAU	State Agriculture University
SDC	Swiss Agency for Development and Cooperation
TCS	TATA Consultancy Services
UPS	User Profiling System
VDC	Village Development Committee
WOTR	Watershed Organisation Trust

Abstract

Climate change is perhaps the most serious environmental threat to fight against hunger, malnutrition, disease and poverty in world. Agriculture is the most vulnerable and sensitive sector affected by climate change because of its dependency on local climate parameters like rainfall, temperature, soil health etc. To alleviate the challenges posed by climate change, agriculture has to become "climate smart", that is, sustainably increase agricultural productivity and incomes, adapt and build resilience to climate change, and reduce or remove greenhouse gases emissions, wherever possible. Despite the recognised importance of Climate-Smart Agriculture (CSA), the dissemination and uptake of climate-smart technologies, tools and practices is still largely an ongoing and challenging process. The adaption of climate-related knowledge, technologies and practices to local conditions, promoting joint learning by farmers, researchers, extension worker and widely disseminating CSA practices, is critical. There is a need for site-specific assessments to identify suitable agricultural technologies and practices needed for CSA. So extension can play an important role in helping the farmers to cope with the diverse impacts of climate change by using appropriate approach to create awareness and make them aware about the different adaptation and mitigation strategies. In this regard, a study was conducted to find out the different extension approaches used in CSA. Three projects – National Innovation on Climate Change, Climate Change Knowledge Network and Climate Change Adaptation – in Maharashtra state were selected. Data collected through an unstructured questionnaire from advisory service provider of selected projects and their beneficiary farmers were analysed. The study found that there were various innovative extension approaches like Disaster Risk Reduction (DRR),Community Based Disaster Management (CBDM), contingency crop planning, appointment of Jaldoot at village, etc. which successfully catered to the needs of the farmers. It was also found that extension approaches varied depending upon the location or weather conditions and in CCA project there was 50% reservation for women's in all the committees.

Executive Summary

Climate is emerging as a prominent issue in the world nowadays. The climate has changed, is changing and will continue to change regardless of what investments in mitigation are made. Climate change is a significant variation in weather patterns occurring over periods ranging from decades to millions of years. Changing climatic conditions most severely affect agriculture because it depends on local climatic parameters like temperature, rainfall, humidity, etc. Climate change directly affects agricultural production as the sector is inherently sensitive to climatic conditions and is one of the most vulnerable sectors to risk and impact of global climate change. Climatic change could affect agriculture in several ways: productivity, in terms of quantity and quality of crops; agricultural practices, through changes of irrigation and agricultural inputs such as herbicides, insecticides and fertilizers; environmental effects, in particular in relation of frequency and intensity of soil drainage (leading to nitrogen leaching), soil erosion, reduction of crop diversity: rural space, through the loss and gain of cultivated lands, land speculation, land renunciation, and hydraulic amenities; adaptation, as organisms may become more or less competitive, such as flood-resistant or salt-resistant varieties of rice. World agriculture faces a serious decline within this century due to global warming. Overall, agricultural productivity for the entire world is projected to decline between 3 and 16% by 2080. Developing countries, many of which have average temperature that is already near or above crop tolerance levels, are predicted to suffer an average 10-25 decline in agricultural productivity by 2080s. Since agriculture makes up roughly 16% of India's GDP, a 4.5-9% negative impact on production implies a cost of climate change to be roughly up to 1.5% of GDP per year. To alleviate some of the complex challenges posed by climate change, agriculture (including forestry and fisheries) has to become "climate smart", that is, sustainably increase agricultural productivity and incomes, adapt and build resilience to climate change, and reduce and/or remove greenhouse gases emissions, where possible. Climate-Smart Agriculture (CSA), contributes to the achievement of sustainable development goals. It integrates the three dimensions of sustainable development (economic, social and environmental) by jointly addressing food security and climate challenges. It is composed of three main pillars: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; reducing and/or removing greenhouse gases emissions, where possible. Extension providers can play a major role in supporting CSA through the following: technology development and information dissemination, strengthening farmers' capacity, facilitation and brokering, and advocacy and policy support. Rural Advisory Services (RAS) contribute to achieving Climate Smart Agriculture (CSA) by disseminating climate information and technologies on production practices for climate adaption through innovative approaches, such as plant clinics and participatory video (Digital Green, case from India), climate-smart villages, climate trainings or workshops, etc. So it is necessary to know the role of extension in CSA and what are the different extension methods used in CSA to help the farmers. Study was conducted in Ahmednagar and Pune districts of Maharashtra state of India because from pre-existing literature it was found that the state is one of the most vulnerable in the country. Three projects – National Innovations on Climate Resilient Agriculture (NICRA), Climate Change Knowledge Network in Indian Agriculture (CCKN IA) and Climate Change Adaptation (CCA) – were selected to study the different extension approaches used by them to cope with changing climatic conditions.

Extension service provider and beneficiary farmers of the projects were interviewed and Focused Group Discussion (FGD), observation method also used for information collection. It was found that different projects used different location-specific extension approaches with different clients. Some of them were climate trainings, climate workshops, contingency crop planning, establishment of automated weather station, use of ICTs for climate change, etc. CCA project used the concept of Jaldoot at the village level. Jaldoot is the local extension worker who provides all the information related to water like how to do water budgeting, promotion of water dams etc. The NICRA project has a different approach- it provides all the agricultural inputs and technology to the farmers to cope with the adverse impact of the climate change, field demonstration of the various adaptation or mitigation technology was done on the farmers' field. CCKN IA was totally ICT based project in which Network for Information on Climate (Ex)Change (NICE)platform (Software) was developed to provide the climatic agro-advisory services to the farmers. So it is important to focus the extension component of CSA while making policy.

Introduction

Agriculture in developing countries must undergo significant transformation if it is to meet the growing and interconnected challenges of food insecurity and climate change (FAO, 2010). Climate change is the most severe challenge that affects development in 21st century. It is one of the major threats to humankind and affects many sectors like forestry, agriculture, environment and human lives as well. Climate change has brought about severe and possibly permanent alterations to our planet's geological, biological and ecological systems. The croplands, pastures and forests that occupy approximately 60 per cent of the earth's surface are progressively being exposed to threats from increased climatic variability. As climatic patterns change, there comes change in the distribution of agro-ecological zones, habitats, distribution patterns of plant diseases and pests, fish populations and ocean circulation patterns which can have significant impact on agriculture and food production. The challenge of rapidly boosting productivity is compounded by the current and expected impacts of climate change. Changes to precipitation and temperature, especially in marginal areas, are expected to reduce productivity and make production more erratic (Cline, 2008; Lobell et al., 2008; Boko et al., 2007). Ensuring that agriculture becomes climate smart is a priority for addressing the need for adequate, nutritionally balanced food for a growing and more demanding population in a situation of resource limitations, and climate change and variability. Consequently, there is a need to simultaneously improve agricultural productivity and reduce yield variability over time under adverse climatic conditions. A proposed means to achieve this is increased adoption of a 'Climate Smart Agriculture' (CSA) approach (FAO, 2010). CSA, which is defined by its intended outcomes, rather than specific farming practices, is composed of three main pillars: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change and reducing and/or removing greenhouse gas emissions relative to conventional practices (FAO, 2013a). So CSA is an important approach in agriculture to deal with the most challenging issue of the world. Much research has been conducted on the biophysical aspect of climate change but socio-economic research regarding the impact of these CSA practices is particularly lacking. So there is a need of strong extension network in climate-smart agriculture to change the behaviour of farmers or to provide them different location specific adaptation and mitigation strategies.

Climate Change and Agriculture

Agriculture is the backbone of economic system of most of the countries. In addition to food and raw material, agriculture also provides employment opportunities to large population. Climate change directly affects agricultural production as this sector is inherently sensitive to climatic conditions and is one of the most vulnerable sectors at the risk and impact of global climate change (Parry et al., 2005). Agricultural production has always been closely linked with variations in weather. Climate change is projected to have significant impacts on conditions affecting agriculture, including temperature, carbon dioxide, glacial run-off, precipitation and interaction of these elements. These conditions determine the carrying capacity of the biosphere to produce enough food for the human population and domesticated animals. The overall effect of climate change on agriculture depends on the various measures adopted to balance these effects.

In general, climate change could affect agriculture in several ways: productivity, in terms of quantity and quality of crops; agricultural practices, through changes of irrigation and agricultural inputs such as herbicides, insecticides and fertilizers; environmental effects, in particular in relation of frequency and intensity of soil drainage (leading to nitrogen leaching), soil erosion, reduction of crop diversity; rural space, through the loss and gain of cultivated lands, land speculation, land renunciation, and hydraulic amenities; and adaptation, (organisms may become more or less competitive, such as flood-resistant or salt-resistant varieties of rice).

The Inter-Governmental Panel on Climate Change (IPCC), in its third assessment report published in 2001, concluded that the poorest countries would be hardest hit, with reductions in crop yields in most tropical and sub-tropical regions due to decreased water availability, and new or changed insect pest incidence (IPCC, 2001). In Africa and Latin America many rainfed crops are near their maximum temperature tolerance, so their yields are likely to fall sharply for even small climate changes. Decreases in agricultural productivity of up to 30% over the 21st century has been projected. Marine life and the fishing industry will also be severely affected in some places. In Asia, agricultural crop yield are expected to decline by 5-30% by 2050s due to rising temperature in Himalayas and this decline in agricultural yield will lead to food insecurity, which becomes a serious future problem for human beings (IPCC, 2007).

In general, climate change could affect agriculture in several ways:

- Productivity, in terms of quantity and quality of crops
- Agricultural practices, through change of water use (irrigation) and agricultural inputs such as herbicides, insecticides and fertilisers
- Environmental effects, in particular, in relation of frequency and intensity of soil drainage (leading to nitrogen leaching), soil erosion, reduction of crop diversity
- Rural space, through the loss and gain of cultivated lands, land speculation, land renunciation, and hydraulic amenities.
- Adaptation, organisms may become more or less competitive, as well as humans may develop urgency to develop more competitive organisms, such as flood-resistant or salt-resistant varieties of rice.

Impact of Climate Change on World Agriculture

Climate change has direct impact on food production across the globe. Increase in mean seasonal temperature can reduce the duration of many crops and hence reduce final yield. In areas where temperatures are already close to the physiological maxima for crops, warming will impact yields more immediately (IPCC, 2007). World agriculture faces a serious decline within this century due to global warming. Overall, agricultural productivity for the entire world is projected to decline between 3 and 16 % by 2080s. Developing countries, many of which have an average temperature that is already near or above crop tolerance levels, are predicted to suffer an average 10 to 25% decline in

agricultural productivity by 2080s. Rich countries, which have typically lower average temperatures, will experience a much milder or even positive average effect, ranging from 8% increase in productivity to 6% decline. Individual developing countries face even larger declines. India, for example, could see a drop of 30 to 40% (Mahato, 2014).

Climate change may lead to an increase in both crop and livestock productivity in mid- to high latitudes (IPCC, 2007) and a decrease in tropical and subtropical areas. The most affected areas from climate change are economically vulnerable countries, already food insecure and some important food exporting countries. This will induce significant changes in trade, impacting prices and the situation of net food importing countries. Consequently, climate change is expected to increase the gap between developed and developing countries as a result of more severe impacts in already vulnerable developing regions, exacerbated by their relatively lower technical and economical capacity to respond to new threats (Padgham, 2009). Smallholders and pastoralists will suffer complex, localized impacts (IPCC, 2007). According to the International Food Policy Research Institute (IFPRI), it will cause an increase of between 8.5 and 10.3% in the number of malnourished children in all developing countries, relative to scenarios without climate change (Nelson et al., 2010).

Agriculture and Climate Change in India

India is an agriculture dependent country and more than two-third of its population depends on agriculture for their survival. Agriculture contributes to approximately 14% to India's GDP. India is a large country with a diverse climate. Diverse seasons mean diverse crops and farming systems. There is a high dependency of agriculture on the monsoon rains and a close link exists between climate and water resources. The impacts of climate change are global, but countries like India are more vulnerable in view of the high population depending on agriculture. In India, significant negative impacts have been implied with medium-term (2010-2039) climate change, predicted to reduce yields by 4.5-9%, depending on the magnitude and distribution of warming. Since agriculture makes up roughly 16% of India's GDP, a 4.5-9% negative impact on production implies a cost of climate change to be roughly up to 1.5% of GDP per year (Venkateswarlu et al., 2013).

People and their livelihood are directly or indirectly affected by climate change. Climate change poses a direct and growing threat to the livelihoods of millions of people in India. Poor rural households, whose livelihoods depend predominantly on agriculture and natural resources, will bear a disproportionate burden of adverse impacts of climate change (Kates, 2000; Mendelsohn et al., 2007; Satapathy et al., 2011).

Yield reductions are predicted in wheat and rice due to temperature rise in key growing regions. 2010 was the warmest year on record in India (+0.93°C) since 1901. The productivity of most cereals would decrease due to increase in temperature and CO_2 and the decrease in water availability. There will be a projected loss of 10-40% in crop production by 2100 if no adaptation measures are taken. A 1°Celsius increase in temperature may reduce yields of major food crops by 3-7% (IPCC, 2007). We

are also going to see increased climatic extremes such as heat and cold waves, which are likely to increase production variability.

According to a study done by the Indian Agricultural Research Institute it was found that there is the possibility of loss of 4 – 5 million tons in wheat production in future with every rise of 1°C temperature throughout the growing period (Kalra et al., 2007). Rice production is slated to decrease by almost a ton/hectare if the temperature goes up by 2°C. In Rajasthan, a 2°C rise in temperature was estimated to reduce production of pearl millet by 10-15%. If maximum and minimum temperature rises by 3°C and 3.5°C respectively, then soybean yields in Madhya Pradesh will decline by 5% compared to 1998. Agriculture will be worst affected in the coastal regions of Gujarat and Maharashtra, as fertile areas are vulnerable to inundation and salinisation.

According to Rao et al. (2011) it was found that kharif (autumn) crops will be impacted more by rainfall variability while Rabi (spring) crops by rise in minimum temperature. Wheat is negatively impacted in Rabi due to terminal heat stress. Rice will be affected both by temperature and water availability. Legume crops such as soybean and groundnut are likely to benefit due to increased temperature/CO2 if water availability is not limited. Milk yield in livestock were impacted during heat waves. The breeding season of marine fisheries were affected with a shift in seasonal catches. There was a negative impact on commercial poultry due to heat stress.

Climate Smart Agriculture and Rural Advisory Services

Agriculture, as both an area of human activity at risk from climate change as well as a driver of climate and environmental change, features prominently in the global climate change agenda. To alleviate some of the complex challenges posed by climate change, agriculture (including forestry and fisheries) has to become "climate smart", that is, sustainably increase agricultural productivity and incomes, adapt and build resilience to climate change, and reduce and/or remove greenhouse gases emissions, where possible (FAO, 2013a). Climate-smart agriculture is defined as an approach for transforming and reorienting agricultural development under the new realities of climate change (Lipper et al., 2014). It is defined as "agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces Green House Gases (GHGs) where possible and enhances achievement of national food security and development goals" (FAO, 2013b). Here productivity, adaptation and mitigation are three interrelating pillars in achieving goal of food security and development in CSA.

CSA is an integrative approach to address these interlinked challenges of food security and climate change that explicitly aims for three objectives:

1. Sustainably increasing agricultural productivity, to support equitable increases in farm incomes, food security and development;
2. Adapting and building resilience of agricultural and food security systems to climate change at multiple levels;
3. Reducing greenhouse gas emissions from agriculture (including crops, livestock and fisheries).

CSA invites to consider these three objectives together at different scales (from farm to landscape), at different levels (from local to global) and over short and long time horizons, taking into account national and local priorities. Achieving these objectives requires changes in the behaviour, strategies and agricultural practices of farming households by:

- Improving their access to climate resilient technologies and practices, knowledge and information for increasing productivity
- Inputs and market information and assistance with income diversification
- Organising them better for collective action.

Rural Advisory Services (RAS) contribute to achieving climate-smart agriculture (CSA) by disseminating climate information and technologies and information on production practices for climate adaption through innovative approaches, such as plant clinics and participatory video (Digital Green, case from India). Extension providers can play a major role in supporting CSA through the following: technology development and information dissemination, strengthening farmers' capacity, facilitation and brokering, and advocacy and policy support. While RAS have a comparative advantage in these functions and are already actively engaged in these roles more broadly, to improve their effectiveness with regard to CSA will require capacity development at individual and organisational level and institutional reform at the systems level.

1. Sustainably increasing productivity and enhancing adaptation through technology development and information dissemination

There is a reform in extension services from transferring skills, technologies and knowledge related to the production of crops, livestock and forestry products from research to farmers, to developing technologies with farmers and catalysing and facilitating innovation processes. This shift in focus is in alignment with the need for site-specific assessments to identify suitable agricultural technologies and practices needed for CSA. RAS disseminate technologies, information and practices with a range of approaches including traditional extension modes (e.g. interpersonal interaction, demonstrations, field days, printed materials, etc.), Information and Communication Technology (ICTs) (radio, mobile phones, video, social media), rural resource centres, farmer-to-farmer extension and farmer field school among others. For example, climate change experts can learn from the experience of RAS in areas such as using ICTs for information dissemination. While technology and information dissemination are traditionally the extension worker's job, RAS providers face challenges in coming up with and disseminating climate-resilient technologies and practices. According to Simpson and Burpee (2014) determining what types of adaptive changes farmers need to make and when to make them, and ensuring that relevant technologies and modes of dissemination keep up with the need for ever-changing climate change adjustments are two key interrelated challenges for RAS providers. To find technical solutions for boosting agricultural productivity sustainably, rural advisors will need new capacities and skills and rural service providers will have to undergo institutional changes. Developing closer linkages between agricultural researchers and extension providers than

currently exists is critical because of the strong need for researchers to tap local knowledge, have a clear understanding of farmers' needs and problems as well as obtain feedback on how technological interventions are working. Climate change adaptation calls for changes in managing natural resources at the landscape level. So RAS providers will need to move beyond their typical focus at household/ farmer level to working at other scales.

2. Building resilience through developing farmers' human and social capacity and providing support services

To manage the uncertainties and risks associated with climate change, diversify their agricultural and income options and become more resilient, farmers need to draw on local and scientific knowledge, sharpen their observational and experimental skills and improve their critical thinking and problem-solving abilities to be able to make their own decisions about appropriate practices and diversified and resilient income opportunities from a menu of options. Human capital is the skills, knowledge, and experience possessed by an individual or population, viewed in terms of their value or cost to an organisation or countryand social capital is the networks of relationships among people who live and work in a particular society, enabling that society to function effectively. RAS uses non-formal education and experiential learning approaches (e.g. farmer field schools, farmer learning groups and local agricultural research committees) that focus on enhancing farmer experimentation and problem solving abilities to encourage uptake and decision making regarding knowledge intensive agricultural practices (Braun, 2000; Waddington et al., 2014). To promote livelihood diversification, some RAS have adopted a market-oriented approach to extension by supporting farmers in the area of marketing, value addition and enterprise skills development. RAS also build resilience after extreme climate events by working closely with humanitarian agencies to distribute seeds and inputs (Christoplos, 2010). Although the role of RAS in building resilience has not been widely documented (Davis et al., 2014), it is clear that strengthening the role of RAS in this area will typically require new skills and capacities at the organisational and individual levels. For RAS providers who are more used to providing technology 'packages and blanket recommendations, building farmers' decision-making and problem solving capacity will require a shift in approach. The need to improve the capacity of rural advisors in 'soft' skills (e.g. communications, facilitation, co-learning, sensitivity to gender and diversity issues, managing power and conflict dynamics, etc.) and in specialised areas such as marketing, must also be recognised, along with the importance of including these competencies in extension education curricula.

3. Supporting climate change adaptation and mitigation through facilitation and brokering

One of the traditional roles of extension organisations is a "bridging" function, linking farmers to other rural stakeholders and service providers. In present times RAS providers in many countries have been supporting agricultural innovation systems (AIS) by playing various roles in the establishment of multi-stakeholder innovation platforms. These include acting as the main innovation broker (the

organisation that catalyses the innovation process and brings the actors together), functioning as a "bridging" organisation facilitating interaction between actors, coordinating and creating networks, supporting actors, facilitating access to information, knowledge and expertise, and providing technical backstopping (Sulaiman and Davis, 2012). According to Leeuwis and Hall (2013) innovation platforms are a kind of institutional innovation that can contribute towards adaptation to, and mitigation of, climate change and are an area where RAS can play a critical facilitation and brokering function for various activities, such as bringing farmers together to develop adaptation practices with researchers and designing climate service tools. Extension providers can help in mitigation by strengthening farmer groups and rural organisations and linking them to voluntary and regulated carbon markets and supporting payment for ecosystem services programs. Besides strengthening existing linkages between farmers and their conventional partners (research, NGOs, traders, input suppliers, credit institutions), rural advisers can also facilitate engagements with new types of institutions related to climate change, such as insurance companies, humanitarian agencies and meteorological services. To support innovation processes, RAS and advisors need skills in areas they typically do not have, such as network building and brokerage, process facilitation and process monitoring.

4. Monitoring, advocacy and policy support

RAS should be actively involved in monitoring the effects of climate change on agriculture and the progress of CSA efforts in close collaboration with farmers and scientists. As one of the key ways policy makers learn about and respond to problems is through dramatic events (Pralle, 2009), by virtue of working closely with farmers and communities, RAS are uniquely placed to highlight the outcomes of climate-related events to policymakers and advocate for policy change and investment in CSA. Enlisting farmers, pastoralists and others directly affected by the changing climate as spokespeople to put a human face to the problem, highlighting potential solutions and providing feedback on policies and progress are some ways RAS can contribute to keeping climate change and CSA high on the policy agenda (Pralle, 2009). Rural advisories can also play a role in explaining climate change policies to rural communities. Extension can also help in conducting the need assessment of the farmers and knowing their awareness level, perception, attitude and vulnerability to climate change; it will help the policy makers to make the location specific polices on the bases of farmers vulnerability level.

Extension Approaches used in CSA

Climate-Smart Agriculture (CSA), as an approach, is a success story and has been rapidly taken up by the international community because of its potential to address the urgent needs of climate mitigation, adaptation and resilience, and food security. While lack of location-specific tools, long-term experiences and a favourable enabling environment are barriers to CSA implementation, there are a number of climate-smart technologies and practices that are known and available. Extension services were traditionally conceived as the mechanism to put research-based knowledge into use with a strong focus on increasing agricultural production. GFRAS (2012) argues that new global challenges such as declining water availability, increasing soil degradation and changing and

uncertain climate and markets means today's role of extension systems has drastically changed. Addressing these global challenges requires generation, adaptation and use of new knowledge, which involves interaction and support from a wide range of organisations. These new challenges also mean that extension systems need to tackle a diversity of objectives that include, but go well beyond, transferring new technology. This encompasses the need to: link more effectively and responsively to domestic and international markets (food, feed, fibres, etc. and/or carbon); reduce the vulnerability and enhance the voice of the rural poor; promote environmental conservation; build linkages between farmers and other agencies; and institutional and organisational development to support the bargaining position of farmers by, for example, forming farmer groups (Davis, 2009). The new extensionist has therefore mutated from a production-centred role to an integrated, cross-sectorial function of the extension ecosystem. Today, extension comes "in many sizes and shapes" and a distinction between the extension approaches as such (e.g. participatory training approach, training and visit approach) or the main underlying principles of the advice (e.g. organic production, integrated production) is not absolute. However, all extension systems share the common challenge of how to best respond to climate change. This is amplified by the fact that CSA considerations in extension strategies can still be considered as new.

There are several ways that extension systems can contribute to CSA. However, the philosophy used (e.g. demand- vs. supply-led, one-to-one interaction vs. mass extension) and specific approaches suit different types of messages to farmers and provide different possibilities to collect information from farmers' fields. In addition, reach and impact potential, two negatively correlated indicators, are of primary importance and differ between extension approaches,i.e. generally, the higher the reach, the smaller isthe impact and viceversa. Mass media often suits simpler messages while intensive interactions through farmer field schools can be more effective for complex knowledge. Choice of approach combinations can influence the ability of extension services to contribute to food security and income, adaptation and resilience, and climate change mitigation.

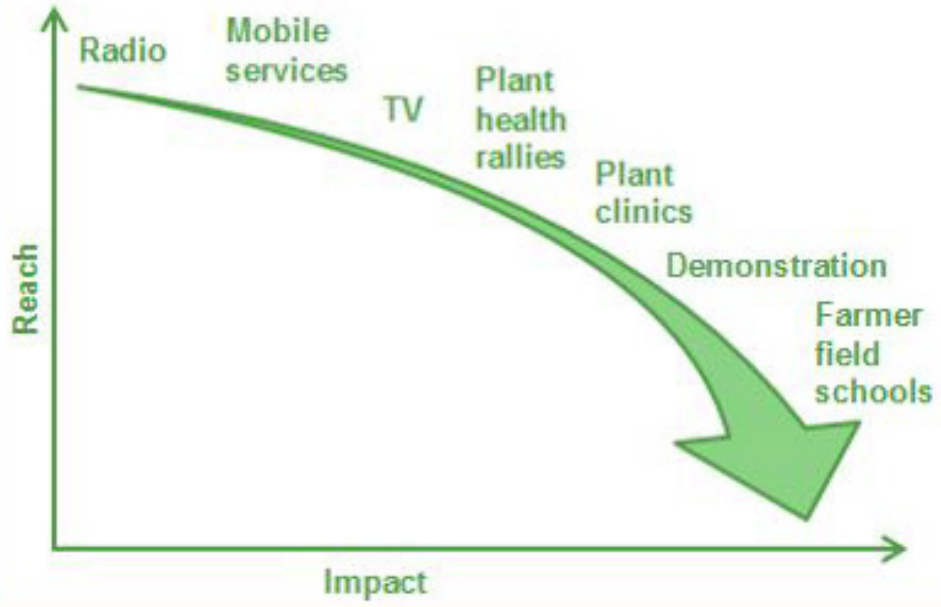


Fig 1: Impact of Extension Approaches (Sala et al., 2016)

There are various innovative extension approaches used worldwide to deal with the adverse impacts of climate change. Some of them are given below:

Table 1: Different approaches used in Extension

Sl. No	Approaches
1	Climate Awareness programmes/Campaigns, Exhibitions
2	Climate Trainings
3	Climate workshops
4	Plant health Rallies
5	Climate Farmers field schools (FFS)
6	Field visits to progressive farmers
7	Demonstration on different adaptation or mitigation practices
8	Dissemination of appropriate climate resilient technology (such as portable soil testing kits, farm mechanization equipment for small holdings, grain storage bags, improved crop varieties etc.), irrigation management.
9	ICT-supported network
10	Participatory crop planning
11	Appointment of climate manager at the village level
12	Appointment of monsoon manager at the district level
13	Use of indigenous technical knowledge (ITKs)
14	Establishment of plant clinics
15	Climate-smart villages

Climate Awareness Mass Media Campaigns: The high reach of mass extension campaign approaches are very attractive. As we know, the major constraints of national extension systems are shortage of field extension personnel and limited resources to reach large numbers of farmers spread widely across geographical areas. To tackle these constraints, extension can be more efficiently performed using mass media. Extension with mass media can also be run by non-extension players (e.g. radio or television) with technical inputs through SMS from extension workers, for awareness creation or simple information delivery. A participatory mass extension campaign in Malawi, for example, has shown positive impact of radio messages on farmers' understanding of climate change and its effects, on how to produce high quality compost or about the importance of compost for building resilience (Mloza Banda, 2014). This example also shows that extension approaches that are best suited for awareness raising have the potential to contribute to climate mitigation, adaptation and increase food security.

Climate Training: Education/training of intermediaries/extension personnel is important to update their knowledge related to climate change, their impacts, and consequences or on different adaptation and mitigation strategies. As we know, climate-smart agriculture is a new and emerging issue so extension service providers should be trained on this. There are various topics in which training can

be given; one component is agro-meteorology, and extension service providers should be familiar to the local meteorology terms and should know how to read the scientific data or interpret it. Extension intermediaries should be closest to the farmers and operate exclusively at field level. They should learn to articulate the needs of farmer communities better and seek for (agro-meteorological) components that need attention. They should match this with what is or should become available as (agro-meteorological) services, in strong contact with the product intermediaries. University education is the fundamental basis for any scientific education that supports the training in searching for solutions at extension level, for which Science Field Shops were established (Stigter and Winarto, 2013). The extension intermediaries trained at that level, for example in Climate Field Schools, train the farmers in Farmer Field Schools (Integrated Pest Management Farmer Field Schools as an existing but deteriorated example), and establish climate services for agriculture with the famers in their fields (Sala et al., 2016)

Plant Clinics: The plant clinic approach is similar to human health clinics; they are the frontline contact point of the national extension system and allow direct information exchange between extension workers and farmers on "any problem and any crop". Plant clinics are a channel for facilitating face-to-face exchange and two-way flow of knowledge and information between extension workers and farmers and link to other components of a plant health system (Boa et al., 2015). The various crop problems brought to plant clinics can be related to either abiotic factors (e.g. nutrient deficiency, waterlogging, chemical misuse, etc.) or biotic factors (e.g. pathogens, insects, rats, etc.). Plant doctors should be knowledgeable about farmers and farming conditions, speak the local language and know what inputs are available. Plant doctors are usually trained extension workers and remain employed by their current organisations. According to Williams (2015), evidence from a recent study shows that 82% of farmers visiting plant clinics in Pakistan, Sri Lanka, Rwanda, Malawi and Ghana reported increasing crop yields due to plant clinic visits.

Climate Farmers Field Schools (FFS): The Farmer Field School (FFS) is a participatory, non-formal extension approach based on experiential learning that puts farmers and their demands at the centre (FAO, 2002). It provides farmers with a low-risk setting to experiment with new agricultural management practices, discuss and learn from their observations, which allows them to develop new practical knowledge and skills, and improve their individual and collective decision-making (Settle et al., 2014). FFSs have also integrated elements of climate change adaption, such as the FAO FFS

Over 1600 plant clinics have been established in 33 developing countries in Asia, Africa, and the America, where farmers can and do ask for assistance on any plant health problem affecting the crops they grow. Sri Lanka, as an example, has already implemented the plant clinic approach in 16 out of 25 districts, with over 290 operating plant clinics.

(Luca heeb, 2016)

program on Integrated Plant and Pest Management (IPPM) that promoted improved and adapted varieties and agro-forestry practices in Mali and Niger (FAO, 2015). Climate Field Schools in Indonesia raised awareness of climate change and promoted solutions to cope with changing rainfall patterns, such as recording and interpretation of on-farm rainfall measurements and in-field water harvesting (Winarto et al., 2008).

A Case from Tanzania

FAO's pilot project on Mitigation of Climate Change in Agriculture (MICCA) in Tanzania is the successful example of a FFSs approach used in CSA. The core principles of Conservation Agriculture (CA) as promoted by the FFSs, were (i) minimum tillage (after double digging is done to break the hard pan from repeated tillage); (ii) permanent soil cover by leguminous cover crops and mulches (as there was no competition with livestock in the area over crop residues); and (iii) crop rotation without the use of slash and burn. The FFSs also encouraged the combination of CA with soil and water conservation practices and agro-forestry. In the three year MICCA project duration, a varying number of FFSs (between five and nine per year) were active, reaching a total of 22 FFSs and about 650 FFS members. Moreover, for the CSA/CC awareness sessions, a total of 1418 farmers (41% women) were reached, around 100 experimental plots were established and 11 tree nurseries (and tree nursery management groups) were set up in the area. The tree nurseries were to provide farmers with seedlings for SWC measures and agro-forestry, offering a range of tree species to satisfy different demands and uses: spices, fruit, timber, fuel wood, construction material and nitrogen-fixing species. Trained nursery managers provided guidance on tree planting and agro-forestry to farmers upon provision of seedlings. In addition to FFSs and targeted training sessions, exchange visits were organized, taking farmers from one village to another in- or outside the project area where the adoption of the promoted practices was further advanced. These exchange visits served also as a reward mechanism for champion farmers and to keep interest and motivation within the FFS. Farmers considered the presence of contact farmers as an important element for the adoption of CSA practices and underlined the value of their knowledge, which will remain in the village beyond the project period and can further support the promotion of CSA. This demonstrates that the FFS approach and CSA have been positively perceived in the targeted communities. Crucial for the acceptance and adoption of a new practice was the demonstration that they actually bring higher yields.

Source- Sala et al. (2016) Supporting agricultural extension towards Climate-Smart Agriculture. An overview of existing tools, Compendium Climate Smart Agriculture and Extension, GACSA

Plant Health Rally Approach: It is an extension method for quickly raising awareness about major agricultural risks or threats on important crops, to promote the use of improved agricultural practices, and to collect feedback from farmers on major issues which affect production. The plant health rally approach, first described by Bentley et al. (2003), is complementary to the plant clinic approach as it differs in terms of reach, impact and complexity of the messages that it can transmit.

Plant health rallies are run by local extension workers. They are usually held in public spaces and are open to everybody. A plant health rally may be spontaneous, attracting people with a banner and other announcements, or may target farmers who have been specifically mobilized for the event. The approach can also contribute to climate change mitigation; for example, plant health rallies would find perfect fit as a vehicle for putting mitigation research (such as urea deep placement technology in rice production) into use and thus reducing greenhouse gas emissions from paddy rice.

As of the end of 2014, almost 290 plant health rallies had been conducted in 14 different countries reaching over 21,000 farmers with targeted messages. Especially in countries like Malawi, Uganda and Zambia, this approach has been used by the public extension system and is valued for its ability to reach a high number of people in a targeted area within a short time (Mur et al., 2013).

Contingency Crop Planning: It is a document that includes the recommendations across the key aspects of crop management and cultural practices. This form of calendar is very useful in terms of crop planting, irrigation scheduling and plant protection measures for farmers. It is done on the bases of local weather conditions for the local crops grown in that particular area. It is participatory in nature because the local knowledge of farmers about the crops or various agricultural practices and scientific knowledge of scientist both plays important role in crop planning. It is prepared with the help of agro-meteorological department.

ICT supported network: The term Information and Communication Technologies (ICTs) played an important role as a medium of information and communication in climate change awareness, adaptation and mitigation strategies. However the availability and adoption of ICTs is varied between areas, developed and developing countries, urban and rural areas and within rural areas themselves. Farmers' ability to perceive climate change is a key precondition for their choice to adapt (Gbetibouo, 2008). Use of mobile phones, videos, radios etc. was done to address the issue of climate change by creating awareness among the farmers about the availability of different adaptation and mitigation strategies.

Case Study

e-Arik (e-agriculture) was an ICT-based project initiated in 2007 in Arunachal Pradesh, India, aimed to disseminate 'Climate-smart agricultural practices' and to achieve food security. Climate-smart farm practices were seen as those that were sustainable, low input and reliant on organic technologies; and focus was on the two major crops of the project area: paddy rice (Oriza sativa) and Khasi mandarin oranges (Citrus reticulate).The e-Arik project established a 'Village Knowledge Centre' with computer, internet link, printer, scanner, phone and TV at Yagrung village. Project facilitators (agricultural professionals, a computer instructor and farmer) were appointed at the centre to help farmers access ICT-based agricultural information. A project portal (www.earik.in) was also created, providing information on crop

cultivation and other agricultural practices, baseline information from relevant agriculture and rural developmental departments of government (including information on objectives, priority areas, administrative and technical personnel details and contacts for the departments of Agriculture, Horticulture, Fisheries, Animal Husbandry and Veterinary, Dairy and the District Rural Developmental Agency) specific information on government schemes such as farmers welfare programmes and day-to-day market information and weather forecasts. Farmers could obtain information directly from the portal, off line CDs or via the facilitator intermediaries to access ICT-based information or to engage in remote consultation with other agricultural experts. The e-Arik project used a wide variety of different ICTs in different ways. Thus, mobile technologies were used to record from the field. Radio and TV were used as a channel for raising general awareness about climate and agricultural issues but not for specific guidance. Videos were sometimes shown via laptop actually in the field in order to communicate specific details of adopting new agricultural technologies. Physical publications were kept in a village library for use when power outages prevented ICTs from being used. Finally, physical display of organic farm inputs at the village knowledge centre was used to stimulate interest and awareness with 90% of visitors recorded as having enquired about availability of the input. The project was successful in demonstrating application of ICTs in promoting climate-smart agriculture practices, new approaches to farming that require few external inputs and which are organic. Such projects must necessarily be driven by the needs and interests of the farmer beneficiaries. For them, climate is an important issue and they recognise signs of climate change. However, their overriding priority and the main aspect that will contribute to the resilience in the face of climate change is increased incomes.

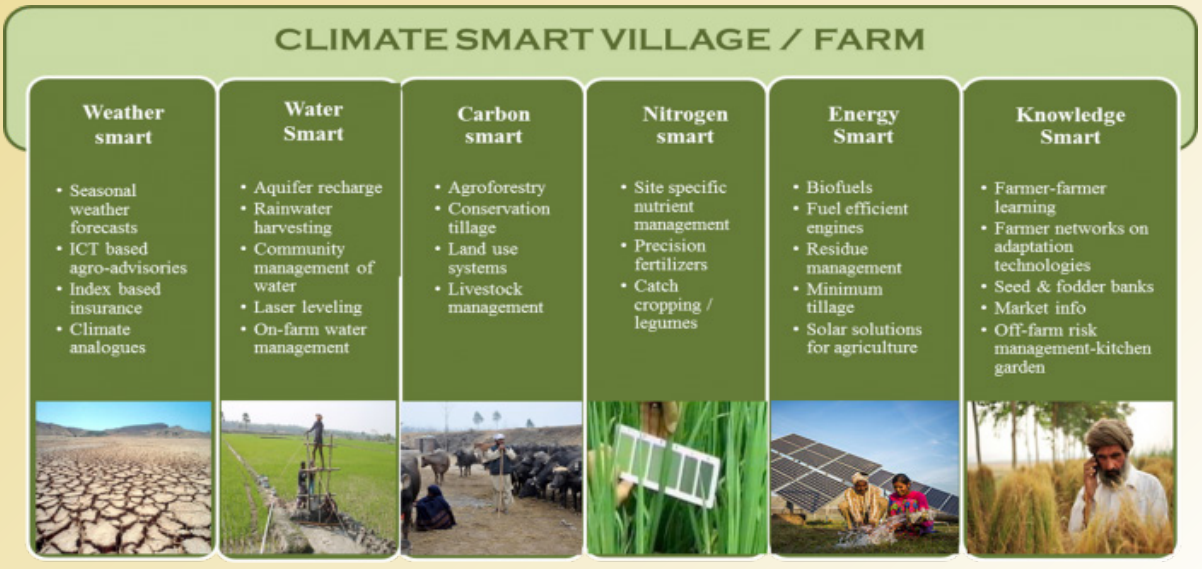
(**Source**- Saravanan, 2014)

Farmer-to-Farmer Extension (F2FE): F2FE is the provision of training by farmers to farmers, often through the creation of a structure of farmer-promoters and farmer-trainers (Scarborough et al., 1997). F2FE offers great promise for effectively scaling up climate-smart agriculture (CSA). The approach empowers farmers as change agents and helps to increase adoption because farmers are more willing to learn from their colleagues than from extension staff (Franzel et al., 2015). F2FE programmes contribute to all CSA, that is, they help improve productivity, build resilience and reduce greenhouse gas emissions. A case in point is the East Africa Dairy Development Project, a project led by Heifer International which had over 4000 volunteer farmer-trainers across Kenya, Uganda, Tanzania and Rwanda since 2008. Farmer-trainers have been instrumental in promoting practices that increase milk production. In Uganda, for example, the trainers are a major reason why over 40% of farmers have adopted seven improved feeding practices, such as sweet potato vines and fodder shrubs (because the project covers different agro-ecological zones, few practices are appropriate for more than half of the farmers) (Kimaiyo et al., 2017.). Some of these practices, such as fodder shrubs, help build farmers' resilience, because they are deep-rooted, drought-resistant and evergreen; thus providing high-protein feed during the dry season, when high-quality feed is scarce. By promoting adoption of perennial fodders such as fodder shrubs, Rhodes grass and Napier grass, farmer-trainers and the project are helping farmers to conserve their soil and reduce greenhouse gas emissions.

Climate-Smart Villages (CSVs): CSVs are the developed villages or models of local actions that ensure food security, promote adaptation and build resilience to climatic stresses. CSV have four components: climate information services; local knowledge and institutions; village development plans; and climate-smart technology. The location of a CSV is selected based on its climate risk profile and the willingness of farmers and local governments to participate in the project. There is no fixed package of interventions or a one-size-fits-all approach. The emphasis is on tailoring a portfolio of interventions that complement one another and that suit the local conditions.

Climate-Smart Villages

The International Maize and Wheat Improvement Centre (CIMMYT), together with the CGIAR Research Programme on Climate Change Agriculture and Food Security (CCAFS), is working with a host of national partners and farmers' organisations in Climate-Smart Villages in Haryana. In 2014, there were 27 Climate-Smart Villages are being piloted in Karnal district of Haryana, in Nilokheri, Indri, Gharaunda and Nissing blocks. The project has seen farmers implement climate-smart agriculture practices such as laser-land levelling, zero-tillage, residue management, direct dry-seeded rice, alternate wetting and drying of rice, precision nutrient management decision-support tools (Nutrient Expert) and sensors (GreenSeeker), agro-forestry, crop diversification and climate information servicesamong others. When used in combination, they show farmers that resource-saving practices can not only save water and energy and make soil healthy but are also economically viable. Farmers profit when they adapt to climate change. Climate-smart agriculture can prepare farmers to respond to the uncertainty that comes with climate change and its impacts on food security and livelihoods.



(Source- CCAFS-CIMMYT, 2014)

Climate-Smart Agriculture in India

As we know CSA is not an option but a necessity to make farmers more and more climate smart. In the line with world, the Indian government also took some initiatives to deal with the challenging issue of climate change. National Action Plan on Climate Change (NAPCC) was launched in 2008 with eight missions. Among them was the National Mission for Sustainable Agriculture (NMSA) to make agriculture productive, sustainable and remunerative and climate resilient and to develop capacity of farmers and stakeholders in the domain of climate-change adaptation and mitigation measures. National Innovations on Climate Smart Agriculture was started by ICAR to enhance the resilience of Indian agriculture to climate change with specific objectives and components in 2011 in 100 selected most vulnerable districts. The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) are leading projects in collaboration with national agriculture research and extension systems. They initiated CSV programmes in Haryana, Punjab, Bihar, Karnataka and Odisha in 2011. In Haryana, CSVs were implemented in close collaboration with NICRA and through a range of innovative partnerships in 2011. The International Maize and Wheat Improvement Centre (CIMMYT) and CGIAR centres, farmer cooperatives, the Haryana Department of Agriculture and policy planners have piloted several CSV in Haryana as research and learning sites. Sustainable intensification and conservation agriculture-based management systems are the key areas in which CIMMYT and our partners work together.The CCAFS project is developing customised, region-specific crop insurance schemes based on short-term and long-term climatic risks.

The Government of India launched various schemes for farmers like soil health card in 2015. Under the scheme, the government plans to issue soil cards to farmers which will carry crop-wise recommendations of nutrients and fertilisers required for the individual farms to help farmers to improve productivity through judicious use of inputs. ICT tools were also used in climate-smart agriculture, such as the use of mobile phone, portals, radio etc. The eArik project was initiated in 2007 in North East India aiming to disseminate climate-smart agricultural practices and also to achieve food security. Climate-smart farm practices were seen as those that were sustainable, low input and reliant on organic technologies; and focus was on the two major crops: rice and Khasi mandarin oranges.

Description of projects

1. Climate Change Adaptation (CCA) project

This project was launched by Watershed Organisation Trust (WOTR) NGO in 2009 to deal with the impact of changing climate on agriculture because agriculture is one of most sensitive sectors affected by climate change. Most of the India's population depends on agriculture directly or indirectly for survival. Changing patterns of temperature and erratic rainfall affect agriculture, which is directly linked to the Indian economy. So it has become important to deal with the changing scenario of climate change in agriculture. CCA was launched in the semi-arid and rainfed regions of Maharashtra,

Telangana, Andhra Pradesh and Madhya Pradesh. There are different partners across sectors and scales-Swiss Agency for Development and Cooperation (SDC), the National Bank for Agriculture and Rural Development (NABARD), respective state governments as financiers and enablers; the Indian Meteorological Department (IMD), The Central Research Institute for Dryland Agriculture (CRIDA), the World Agro-Forestry council (ICRAF) and the Mahatma Phule Agriculture University (MPKV) and Bharati Vidyapeeth Institute of Environment Education and Research (BVIEER) as technology and knowledge partners, and WOTR which implements it generates and validates knowledge for use. The project was closed in 2015.

Table 2: Scenario of the CCA project

S. No.	States	Districts	Villages	Area
1	Maharashtra	Ahmednagar Aurangabad	35	22,916 ha
2	Madhya Pradesh	Mandla district	8	2859 ha
3	Andhra Pradesh	Kurnool district	3	4331 ha
4	Telangana	Mahboobnagar	3	
			Total	**46,915 ha**

(**Source**-WOTR, 2009)

2. National Initiative on Climate-Resilient Agriculture (NICRA)

National Initiative on Climate Resilient Agriculture (NICRA) was launched during February 2011 by Indian Council of Agricultural Research (ICAR) with funding from Ministry of Agriculture, Government of India. The mega project has three major objectives: strategic research, technology demonstrations and capacity building. The major aim of NICRA is to enhance the resilience of Indian agriculture, covering crops, livestock and fisheries to climatic variability and climate change through development and application of improved production and risk management technologies; to demonstrate the site-specific technology packages on farmers' fields for adapting to current climate risks; and to enhance the capacity of scientists and other stakeholders in climate-resilient agricultural research and its application.

Objectives

1. To enhance the resilience of Indian agriculture covering crops, livestock and fisheries to climatic variability and climate change through development and application of improved production and risk management technologies.
2. To demonstrate site-specific technology packages on farmers' fields for adapting to current climate risks.
3. To enhance the capacity of scientists and other stakeholders in climate-resilient agricultural research and its application.

The project comprised of four components:

1. Strategic research through network as well as Sponsored/Competitive Grants mode
2. Technology demonstrations on farmers' fields to cope with current climate variability
3. Knowledge management
4. Capacity building of different stakeholders.

3. Climate Change Knowledge Network in Indian Agriculture (CCKN-IA)

CCKN was German development cooperation (GIZ) and the Ministry of Agriculture and Farmers Welfare project established in 2013 in selected districts of three states – Maharashtra, Jharkhand and Odisha – to establish ICT-enabled approaches for knowledge exchange on climate-change adaptation in Indian agriculture. It promotes interactive dialogues among different stakeholders to establish and enhance linkage between climate change and sustainable development in agriculture.

Rationale of Study

From the above discussion it was found that extension has a wide scope in CSA from serving as an intermediary between research and farmers to functioning as nodal points bringing together and facilitating multiple stakeholders to address complex problems and situations of climate change. It was found that the extension system tends to be weak and unsystematic, characterised by short-term projects, a lack of coordination between providers, limited financial and human resources (particularly for public sector agencies) and advisers who lack the knowledge and skills to address the challenge of climate change. To handle the complexity of achieving CSA and to ensure the efficiency, there is need for effective rural advisory systems; this encompasses the organisations and actors involved in providing extension and closely related services (education, research, agribusiness support, etc.), the regulatory and policy structures that govern how the system operates, and the enabling environment.

So to make the extension system climate sensitive there is a need to analyse the different approaches used by the extension providers in climate knowledge, learning and capacity development; whether these approaches are gender sensitive or not; and what are the constraints faced by the extension provider in technology transfer. There is also need to analyse the farmer's perspective whether these methods were effective in real field conditions or not. So, to answer these questions a research project titled' Climate Smart Agriculture and Advisory Services: Approaches and Implications for Future' was proposed with the following objectives:

1. To study different innovative extension methods used in climate knowledge, learning and capacity development in climate-smart agriculture.
2. To determine the farmers' opinions on performance of extension methods used in field condition.

Climate Change Context in Maharashtra State

According to the World Bank Project on Climate Resilient Agriculture 2017, the state of Maharashtra is one of the economic growth engines of the country. It is the top-ranked state in terms of contribution to the national GDP (14.4%, 2014-15) and has witnessed an average economic growth rate of over 8% per annum over the last decade, with 9.3% of the country's population and 9.4% of the country's geographic area. In Maharashtra, agriculture has grown at an annual average of 6.4% from 2004-05 to 2011-12, but growth in the sector fluctuates heavily and is dependant on highly erratic rainfall during any particular year and rainfall variability over time. The distribution of rainfall is highly uneven within the state and ranges from over 4,000 mm per annum in coastal areas to less than 400 mm in some of the most arid districts. Agriculture remains the highest user of freshwater, withdrawing more than 80% of the surface and groundwater available to the state. Severe consecutive droughts experienced in large parts of Maharashtra over the last two years have considerably affected the state's agricultural performance and social fabric in rural areas, and have prompted the highest-level state authorities to declare 'drought-proofing' of agriculture a key development priority for Maharashtra. Maharashtra's agriculture is dominated by small and marginal farmers with an average farm size of 1.44 ha. Most of the agricultural production is rainfed, with less than 20% of the arable land under irrigation. The annual mean temperature in Maharashtra is projected to increase by around 1.3-1.5˚C by the 2030s; the projected increase in monsoon rainfall by the 2030s ranges from 13-30% across the state (IPCC 2014). The effects of these longer term climate trends on sectors like agriculture or water, effectively signalling a shift in climatic conditions, will be further aggravated by the projected increase in the frequency of extreme climate events (droughts, hailstorms, floods, delays in the onset of monsoons, higher rainfall intensity) already experienced in Maharashtra over recent past, as illustrated by the three severe droughts that hit the state over the past five years.

Research Methodology

Description of the locale of study

Maharashtra is a third largest and second most populated state which occupies a substantial portion of the Deccan Plateau and is one of the most industrialised states of the country contributing about 13% of national industrial output. Despite its high industrialisation, agriculture continues to be the primary occupation employing over 64.14% of its populace. It is this high dependency on climate-sensitive sectors like agriculture, and a long coastline of over 840 km that make the state vulnerable to the impacts of climate change including changes in temperature, precipitation pattern, increase in the frequency and intensity of extreme events including droughts, floods, cyclones, storm surges, heat waves and so on. According to The Energy and Resources Institute (TERI) report, sea level rise of one metre will inundate 0.18% of Maharashtra, putting 1.3 million people at risk. Sugarcane yield in Maharashtra could go down by 30% under climate change. A study conducted by TERI has identified Maharashtra as one of the most vulnerable states in the country. Based on biophysical, social and technological indicators the state has low' adaptive capacity' to climate change, which means that its potential to respond successfully to climate variability and change, including adjustments in resources and technologies is very low.

According to CRIDA report on demonstration of climate-resilient technologies on farmers' fields in a National Initiative on Climate Resilient Agriculture (NICRA) project, out of all the vulnerable districts selected from India, seven were from Maharashtra alone due to severe attack of drought. These districts were Pune, Aurangabad, Amravati, Ratnagiri, Ahmednagar and Gondia. Institutes working on climate change in Maharashtra are NICRA by Indian Council of Agriculture Research (ICAR), Maharashtra State Action Plan on Climate Change (SAPCC), Climate Change Knowledge network (CCKN) by GIZ (technical cooperation with German Development Cooperation), GOI (Government of India, Ministry of Agriculture and Farmers Welfare), and MANAGE (a national consortium facilitating agency). Climate Change Adaptation project (CCA) by National Bank for Agriculture and Rural Development (NABARD), the Swiss Agency for Development and Cooperation (SDC) and Watershed Organization Trust (WOTR) is working in four states Maharashtra, Madhya Pradesh, Andhra Pradesh, and Telangana. In Maharashtra, 58 villages were selected from three districts (Ahmednagar, Aurangabad and Jalna) and 25 villages in Akole and Sangamner block of Ahmednagar district.

So, on the basis of review of literature of different publications from different institutes like CRIDA, ICRISAT, GFRAS etc. it is clear that Maharashtra is one of the vulnerable states suffering from adverse impacts of climate change. So it will be selected purposively to form the locale for the present study because out of the 100 most vulnerable districts in India, seven districts – Nandurbar, Pune, Aurangabad, Amaravati, Ratnagiri, Ahmednagar and Gondia – were from Maharashtra state only. In CCKN project, only three states of India (Maharashtra, Chhattisgarh and Odisha) were selected for pilot study and out of these, one state was Maharashtra. It means it is one of the severely affected states due to adverse impacts of climate change. So there is a need to study or to explore the various extension approaches used in climate-resilient technology transfer.

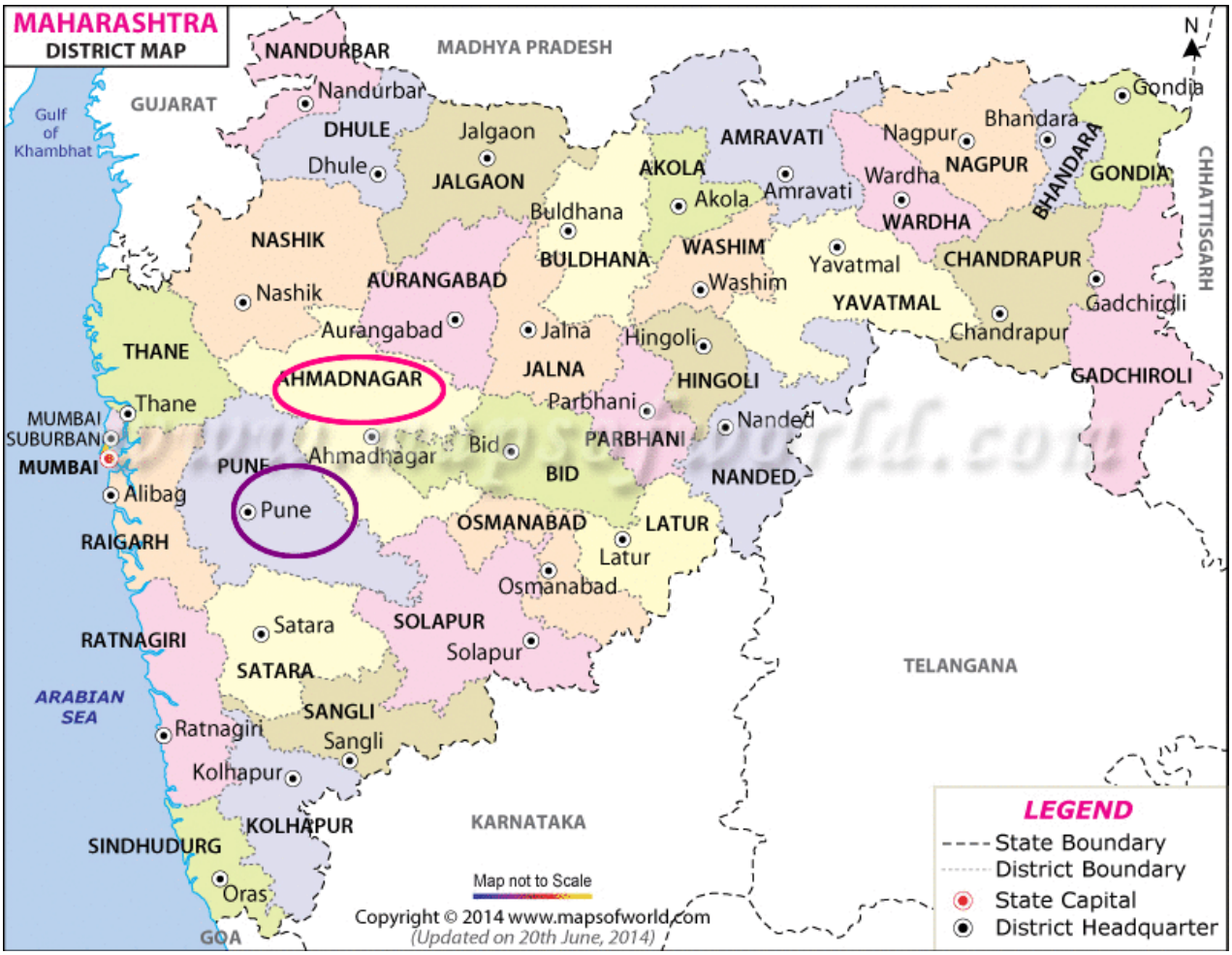


Fig 2: Map of Maharashtra state

Area of Study

It was found from reviewing the CRIDA report that seven most vulnerable districts of Maharashtra are Nandurbar, Pune, Aurangabad, Amravati, Ratnagiri, Ahmednagar and Gondia; out of these, Pune and Ahmednagar were selected purposively because NICRA, CCKN and CCA programmes are working there.

From the review of literature of different projects, it was found that most of the climate-resilient projects or programmes are running in Ahmednagar and Pune district of Maharashtra. KVK Babhaleshwar from Ahmednagar, KVK Baramati from Pune District, a WOTR Pune, ATMA (Agricultural Technology Management Agency) Ahmednagar, IMD (Indian Meteorological Department), SAU (Mahatma Phule Krishi Vidyapeeth), Rahuri and some other organisations working there were selected to collect the data for the first phase. Different project beneficiary villages were visited to collectdata on farmers' opinions on performance of extension methods used in field condition for climate knowledge, learning and capacity development.

Table 3: Project Scenario

S. No	Name of Project	Implementing Agency	District	Block	Institute working
1.	National Innovations on Climate Resilient Agriculture (NICRA)	ICAR	Ahmednagar	Rahata	KVK Babhaleshwar
			Pune	Baramati	KVK Baramati
2.	Climate Change Knowledge Network in Indian Agriculture (CCKN-IA)	GIZ, GOI, MANAGE	Ahmednagar	Nagar	KVK Dahigaon
				Rahata	KVK Babhaleshwar
			Pune	Junnar	KVK Narayangaon
				Velhe	KVK Baramati
3.	Climate change adaptation (CCA)	WOTR	Ahmednagar	Akole	WOTR Pune
				Sangamner	

Selection of Respondents

Extension service providers and stakeholder farmers both formed the sample size of the present study. Different extension service providers were selected from the above listed climate-smart agriculture related projects. List of different stakeholders involved in these projects was prepared by using secondary or published data collection. Some other projects working on climate change was identified with the help of these stakeholders. Stakeholder farmers of different projects were selected to collect the data for my second objective with the help of Probability Proportional to Size (PPS) method.

Research Design

For the purpose of this study mixed method was used that involves initial rapport building, preliminary qualitative and quantitative study in the geographical area of the target population. A semistructured interview schedule was prepared to study the different extension methods and strategies used in these project and farmers' opinions on these methods. Other than this, focused group discussion (FGD) and observation methods were also used to support the information.

Data collection

Data was collected in three phases.

First Phase: Different climate-related projects use different methods or approaches in climate-related knowledge generation and capacity development. Data or information on the different agricultural extension methods or approaches used in climate knowledge, learning and capacity development for farmers was collected after reviewing the annual reports, research papers and online published reports, books, magazines etc.

Second Phase: Extension service providers or field extension agents were interviewed in groups or

individually in the district offices of selected study areas with the help of unstructured schedules or interview guide. From the interview with extension advisory service providers, different methods like above were identified. For CCA project, the Deputy Director of WOTR office, Pune, Project In-charge and field staff of Ahmednagar and Sangamner office were interviewed. For NICRA and CCKN-IA project, KVK Head or Project Coordinator of Narayangaon, Baramati, Bhabaleshwar were interviewed to collect the information.

Third Phase: Stakeholder farmers of these three projects were selected through Probability Proportional to Size (PPS) method. Farmers were interviewed in groups or individually, using semistructured schedule to find out their opinion on performance of various extension approaches used by extension service providers. FGD were conducted among the groups of men or women farmers. Observation method was also used to support the collected data. Both interview and FGD were auto-recorded with the help of a recorder.

Tools and techniques used for data collection

The study used both primary and secondary data. With the help of secondary data, different projects working on climate change were identified and the project under study was selected. Secondary data sources were utilised to provide background and other necessary information to achieve the objectives of the study. Sources of secondary data included textbooks, journals, conference proceedings and other relevant publications of the institutes working on climate change. Primary data was collected by conducting face-to-face interviews with the extension service providers and farmers with the help of unstructured schedules. Focus Group Discussions (FGDs) were conducted with the groups of farmers. In this study, observation technique was also used to enrich the data and verify the responses of the respondents. Transect walk technique of Participatory Rural Appraisal (PRA) method was also used to know the location or farming land pattern of the villages.

Analysis of data

A wide variety of data was summarised and categorised in different ways for ease of presentation and comprehension.

Result and Discussion

Climate Information Services

Reducing vulnerability to climate risks in the present is necessary for adapting to climate change in the future, as vulnerable farmers experience climate change largely as shifts in the frequency and severity of extreme events (Cooper et al., 2008). Extreme events erode livelihoods through loss of productive assets, impaired health and destroyed infrastructure, while the resulting uncertainty is an impediment to adoption of climate-resilient practices, and to the transformational change required to adapt to climate change (Hansen et al., 2014). In risk-prone environments, efforts to foster the transition toward more productive and resilient agricultural livelihoods must therefore be supported by strategies, programmes and policies that enable vulnerable populations to overcome the obstacle of climate risk. With enabling institutional support and policies, value-added climate information and advisories reduce this uncertainty, and enable farmers to better manage risk, take advantage of favourable climate conditions, and adapt to change. Different forms of climate information helps farmers to make informed farming decisions. As we know, extension is the main department which directly deals with the farmers to give them information or enhance their capacity to increase their productivity, so that they adapt to climate change. So there is an emergence of some extension methods which helps the farmers to fight against climate change. Availability of adaptation or mitigation technologies is not sufficient for farmers unless they are aware about climate change consequences and are ready to fight them. So here extension plays a major role in the changing climate scenario by providing them climate-smart information at the right time.

Table 4: How farmers around the world are making decisions based on weather and climate information

	Types of information	Tools for delivering information	Farmers decisions affected
Weather (Days to week)	• Observed rainfall & temperature • Daily forecast alerts on pests and diseases • Warning of extremes weather events	• Mobile phones • Radio • Television	• Timing of planting or harvesting • Timing Of fertiliser, pesticide and irrigation application • Protecting lives and property from extreme events
Climate Variability (Months to Year)	• Probabilities of seasonal rainfall &temperature conditions • Seasonal climate variability targeted to particularly agriculture risks (like dry spells, rainy season, flood start day etc.) • Historical variability of climate variables.	• Workshops with experts • Conversations with agricultural extension agents or farm educa-tors	• Selecting crops and varieties • Livestock stocking rates and feeding strategies • Intensity of input use (fertiliser, pesticides) • Labour or marketing contracts • Intensifying or diversifying crops • Diversifying sources of income

	Types of information	Tools for delivering information	Farmers decisions affected
Climate Change (more than 10 years or longer)	• Future rainfall & temperature projections. • Historical trends of rainfall and temperature • Historical changes in extremes events.	• Workshops with researchers, agri-cultural exten-sion agents and meteorological services.	• Major capital investments like buying or selling of landholding, irrigation system, farm equipment etc. • Changing farming system or livelihood strategy • Deciding whether or not to farm

(**Source**-Dinesh, 2016)

Innovative Extension Approaches for Climate-Smart Agriculture: NICRA, CCKN-IA and CCA project

1. Extension Methods for Transfer of Climate Knowledge

Different projects used different approaches, strategies and methods to deal with the changing climatic conditions in the field situation or to help the farmers. Out of these three projects, two projects NICRA, CCKN-IA were under government organisations (ICAR) and one CCA was under NGO so they all used different methods for climate knowledge transfer based on the location/area where they worked. Most of the adaptation activities in the study area were done by WOTR under the CCA project, and it worked efficiently for the farmers. NICRA aimed at enhancing resilience to climate change through technological interventions while CCKN's main focus was on use of Information and Communications Technology-based (ICT-based) knowledge platform to improve processing, sharing and use of knowledge around climate change adaptation in agriculture while CCA adopted the knowledge-informed, multidisciplinary and participatory approach which includes various sub components.

Effective adaptation of the CSA advisories generated by different project can only be achieved if farmers had sufficient awareness and knowledge on climate change issues, like what is climate change, how it is affecting the agriculture, what are the consequences and impact and so on. So different projects used different methods according to their clients, location and objectives, some of them are discussed below.

SMS or Short Messaging Services: Short text messages of 160-164 characters in the local language (Marathi) was sent to registered mobile numbers of farmers. Maximum two SMS per week based on weather advisories and contingency plans were sent to the farmers.

Climate Wallpapers: One-page advisories in the form of tables or posters related to weather prediction of agricultural operations needed to be performed were pasted on common display boards of villages to provide advisory services to the farmers. In CCA project, these advisories were named Krishi Salah.

Climate Voice Messages: SMS was converted into voice messages in the areas with low literacy rate and disseminated to the farmers.

Folk media: Some nukkad natak (street plays) related to effect of climate change on agriculture were prepared under the CCA project, so farmers could know more about the changing climatic conditions.

Use of Public Addressing System (PAS): It was a good tool for any urgent information dissemination to the villagers like in the villages where SMS was not delivered due to network and electricity problems, farmers were informed about the critical climatic conditions or agro-advisory services was given with the help of this. For example, if rainfall was expected the next day, farmers would be immediately informed so that they could plan their farming activities accordingly. In Pathar, one cluster of Sangamner block, one permanent PAS is located in a temple of the village for public announcements related to climatic conditions.

Climate Group meetings: Farmers were organised in a group because it is easy to connect them or to disseminate climate-related information to them in a group. Various committees were formed in the village to look after different components like under CCA project village development committee (VDC) were formed. There were 10-15 members in a committee and there was also 40-50 % reservation of women's in all the committee.

Exposure visits were conducted for the farmers in the fields of progressive farmers such as those who grow pomegranate, use organic slurry for their crop, use drip or sprinkle irrigation etc. so that they were also motivated to adapt these mitigation measures.

Climate Workshops: Various workshops on different topics like preparation of water ponds, pomegranate cultivation, use of organic fertiliser, custom hiring centre etc. were conducted to make farmers aware.

2. Extension methods for learning

Climate Field Group Visits- It was observed that for the creation of location-specific agricultural information, content team must visit the project sites twice in a season: first at the start of the season, followed by middle of the season. The objective of the visit is to collect information about actual field condition, agro-meteorological issues, ongoing government schemes etc.

Farmer Interest Groups (FIGs) – Promotion of FIGs was done to organise them in a group on the basis of their commodity or enterprise because it is easy for dissemination of information. There were different groups in the villages (both men and women) such as the group of poultry-rearing farmers, goat-raring farmers, women SHGs, etc. FIGs make it easy to provide them with customised information. So it saves the time of both farmers as well as service providers. It was found that all activities promoted through FIGs were more effective.

Climate Trainings – It was given to the agricultural extension workers to decide how to use NICE platform to give advisory services to the farmers and how to collect feedback of the farmers in CCKN project. Rain gauges installed in farmers' field and as per the norm of Indian Meteorological Department (IMD), KVK experts are in direct contact with these farmers to collect rainfall data. IMD provided technical material and field training to KVK experts and farmers on importance of rain gauges and how to install rain gauges at field level. Training was also given to the youths or farmers of the village how to read data from automated weather station or how to read temperature or how predict that information.

Informative Crop Calendar- It is a type of calendar which provide all agricultural practices package (information) of the crops. It includes planning, irrigation scheduling and plant protection measures based on the weather-based management. It was based on the area or specific cropping pattern of that particular area. Under CCA project, a crop calendar was prepared with the help of CRIDA for the key crops grown on the Akole or Sangamner block of Ahmednagar. It includes weather-specific crop advisory services of specific crops like for paddy, finger millet, groundnut etc.

Livestock Calendar- Livestock is an important component of livelihood that not only supports the income of the farmers but the output also helps them in organic cultivation practices. During interactions with farmers, it was noted that farmers were not aware of any proper livestock management, government schemes, vaccination schedules etc. This reflects not only in the health of livestock but also the quantity and quality of the products. Under CCKN, a similar calendar on livestock with monthly advisories, government schemes, vaccination schedules, best practices etc. were published and distributed to the farmers, higher authorities and extension officers.

Block Contingency Planning- Contingency plans are technical documents containing integrated information on agriculture and allied sectors i.e., horticulture, livestock, poultry, fisheries and technological solutions for all the major weather-related aberrations including extreme events viz., droughts, floods, heat wave, cold wave, untimely and high-intensity rainfall, frost, hailstorms, pest and disease outbreaks. CRIDA prepared these documents which are aimed to be utilised by district authorities. However, a constantly felt need for localising these plans further at block level to effectively tackle the local impacts was the key motivation for this entire innovative approach.

Information & Communication Tools- NICE (Network for Information on Climate (Ex)Change) platform is an IT-based system that facilitates gathering and disseminating up-to-date and relevant information to the farmers for sustainable agriculture used under CCKN IA project. Mobile phones were also used to send weather-based crop advisories to farmers.

3. Extension methods for capacity development

Climate Trainings- Training was given to farmers on different adaptive or mitigation practices, including mulching, SRI cultivation, use of organic fertilisers, use of javaamrit and organic slurry, construction of polyhouse, drip irrigation, growing of less water-intensive crops in the area, dairy, poultry and goat rearing, silage making etc.

Climate Workshops- Workshops on different topics such as preparation of water ponds, pomegranate cultivation, use of organic fertiliser, custom hiring centre, crop insurance etc. was conducted to make farmers aware.

Field Demonstration- Field demonstration was undertaken for management of bacterial disease in pomegranate. The farmers were asked to adopt proper management practices like application of organic manures, neem cake, vermicompost and bio-fertilisers. Similarly, the awareness has also been created regarding importance of mulching to reduce soil temperature. Demonstration on rearing of Srinidhi or Vanaraja breeds of poultry for backyard poultry for egg and meat purpose and drumstick plantation was given.

Climate-Smart Farmers Field Schools (CFFS) – The Farmer Field School (FFS) is a participatory, non-formal extension approach based on experiential learning that puts farmers and their demands at the centre (FAO, 2002). It consists of a group of 20-25 farmers from the village who meet weekly throughout growing seasons at a test field of climate-resilient technology like use of in situ moisture conservation, use of organic slurry in pomegranate field etc. The farmers compare conventional and new, innovative production and management practices on separate plots. The FFS is guided by trained facilitators like extension workers, NGO workers, farmer organisation staff or trained farmers. Climate-smart Field Schools is effective in advancing local-level climate-smart interventions (Sala et al., 2016). Climate-resiliency Field Schools have promoted the practice of organic farming, various systems for rice intensification, and the establishment of community seed banks and other practices, such as soil conservation, reforestation, and agro-forestry for increasing crop production. Climate-resiliency Field Schools serve as a multilevel institutional platform where farmers can access climate information, which they can use to improve farm planning (i.e. choices of crops, timing of farm preparation, and harvest). Climate Smart Farmers Field School in Indonesia raised awareness of climate change and promoted solutions to cope with changing rainfall patterns, such as recording and interpretation of on-farm rainfall measurements and in-field water harvesting (Winarto et al., 2008).

Weather-Based Insurance- Well-designed and targeted agricultural insurance can enable farmers to re-invest in inputs and technologies despite bad years. 100% farmers used crop insurance scheme to protect their crops from any hazards in the study area. It was stated in the notes of CGIAR that in India, 30 million farmers are covered under crop insurance schemes to protect their crops from climate change.

Community Based Disaster Management (CBDM) approach– WOTR has developed a community-based disaster management (CBDM) approach to build capacity of communities to reduce the impacts and to cope with disasters more effectively. Community participation and ownership in disaster risk reduction (DRR) is the key to minimising losses. Under this, disaster risk reduction clock of a village was prepared under which the points or places of the villages which are sensitive to climatic disaster were identified and then training was conducted for the villagers to make them aware of it. Mock safety drills were also conducted for school children or villagers.

Village Level Custom Hiring Centre (CHCs)- Mechanisation brings in timeliness and precision to agricultural operations, greater field coverage over a short period, cost-effectiveness, efficiency in use of resources and applied inputs, Custom Hiring Centres (CHCs) for farm implements were established in the villages which could successfully empower farmers to tide over the shortage of labour and improve efficiency of agricultural operations. The most popular implements kept in the centre are rotavator, zero till drill, drum seeder, multi-crop planter, power weeder and chaff cutter. A committee of farmers nominated by the Gram Sabha manages the custom hiring centre. The rates for hiring the machines/implements are decided by the Village Climate Risk Management Committee (VCRMC) in NICRA project. While in case of CCA project, approach of custom hiring centre is same but managed by different committee which is known as village development committee (VDC).

Case study- Disaster Risk Reduction (DRR)

Awareness campaigns have been organised by WOTR team to sensitise the village, to plan, review and analyse past disasters. DRR clock and seasonal disasters have been prepared for likely seasonal disasters. Community Driven Vulnerability Evaluation-Visual Integrator (CoDrive-VI) tool guides the construction of a 3D model of the cluster of villages to assist communities to identify hazard spots, safe spots and how to address to adverse situations. Once hazard spots like road caving-in sites, weak houses/walls are identified, the actual location in the village is marked and the respective government departments and households are contacted for action. WOTR has initiated DRR interventions in 33 villages across Maharashtra and Madhya Pradesh. In all villages participatory 3D models were prepared for the villages and clusters, where hazard spots, vulnerability zones and safe spots were marked. Each village has phone numbers of respective local authorities displayed in public sites for immediate contact in times of need. Safety mock drills were conducted in schools, to train teachers and children about how to respond to potential disasters. Sensitisation meetings were conducted for hazard-specific mitigation activities etc. DRR workbooks and plans have been prepared for project villages. For example in the Parthala village of MP high tension electric wires were within easy reach of adults, so by realising the potential disaster that could be caused, the VDC reported same to the electricity board, which immediately rectified the situation.

Jaldoot, community-level extension professional- Jaldoot is a local person familiar with the local climatic conditions, cropping patterns and peoples. He acts as a local extension worker who has knowledge on all water-related activities. He helped the farmers in different activities involved in water budgeting, construction of water ponds, bore wells etc. It was a good initiative undertaken by WOTR and it helped the farmers mainly in how to plan their crops according to water availability. Any farmer who needs any information related to water can contact Jaldoot. It is important for the drought areas where the main problem of farmers was water scarcity, so it is a good intervention done by WOTR to capacitate the farmers to deal with the changing climatic conditions.

Agro-meteorological Advisory Service- It provides location-specific agro-advisories on weather forecasting, associated agricultural advices and a phone-in help desk for farmers. For this purpose,

local automated weather stations were set up in the villages and daily weather information was collected through GPS. After analysis advisory services were provided to the farmers. On the basis of this, farmers plan their agricultural activities which help them to adopt to the changing climatic conditions.

Case study: Automated Weather Stations

Awareness campaigns have been organised by WOTR team to sensitise the village, to plan, review and analyse past disasters. DRR clock and seasonal disasters have been prepared for likely seasonal disasters. Community Driven Vulnerability Evaluation-Visual Integrator (CoDrive-VI) tool guides the construction of a 3D model of the cluster of villages to assist communities to identify hazard spots, safe spots and how to address to adverse situations. Once hazard spots like road caving-in sites, weak houses/walls are identified, the actual location in the village is marked and the respective government departments and households are contacted for action. WOTR has initiated DRR interventions in 33 villages across Maharashtra and Madhya Pradesh. In all villages participatory 3D models were prepared for the villages and clusters, where hazard spots, vulnerability zones and safe spots were marked. Each village has phone numbers of respective local authorities displayed in public sites for immediate contact in times of need. Safety mock drills were conducted in schools, to train teachers and children about how to respond to potential disasters. Sensitisation meetings were conducted for hazard-specific mitigation activities etc. DRR workbooks and plans have been prepared for project villages. For example in the Parthala village of MP high tension electric wires were within easy reach of adults, so by realising the potential disaster that could be caused, the VDC reported same to the electricity board, which immediately rectified the situation.

Contribution to Enhancing Food Security, Resilience and Productivity in a Sustainable Manner:

The provision of weather information and associated advisories contributes to enhancing food security, resilience and productivity in a sustainable manner, from several important perspectives.

1. Productivity/food security: Since climate-related risk is often a barrier to adopting climate-resilient technologies and to making the transition toward more productive

agriculture, effective climate services foster adoption of improved technology and facilitate the transition toward more climate-resilient agricultural systems. Timely weather and climate information contributes to productivity by supporting farmers' decisions such as choice of variety and production technology, and timing of planting etc.

2. Resilience/adaptation through short-term risk management: The effective use of weather information services contributes to resilience by enabling farmers to better manage the negative impacts of weather-related risks in poor seasons, while also taking greater advantage of average and better than average seasons.
3. Mitigation co-benefits: By better matching the use of fertiliser and other production inputs with year-to-year climatic conditions, the existing evidence suggests that climate services can make a contribution to mitigation by supporting more efficient use of fertilizers.

Farmers' Opinions on Performance of Extension Methods Used in Field Condition

Farmers were most satisfied by CCA project because it promoted the integrated farming system in the most drought-prone areas of Maharashtra. All villagers are aware about the project and their activities. Water wells with solar system were promoted in areas with no source of electricity. It helps the farmers to irrigate their crop without electricity motor. Water budgeting is the important initiative under CCA project which helps the farmers to calculate the amount of water needed by their crops and plan accordingly. It is a group approach used to bring the farmers together in one platform. Farmers get the accurate weather information because of automated weather stations and consequently, accurate weather advisories. Women are equally benefited from this project because there was 50% reservation for women in each committee and activity. This helps women to get more exposure and participation in agricultural activities. It also builds their confidence and increases their decision-making ability. Crop calendars were prepared on the basis of water availability or soil nutrient status. Every farmer of the village had a soil health card, which helps them in crop planning. From the farmers' interview it was found that farmers were satisfied from extension services, they received all the information timely. Extension service provider visited them fortnightly.

Farmers were satisfied from the project, especially those from Jalgaon village. Before implementation of NICRA, source of income in the village was scarce and they totally depended on agriculture. Crops were grown only during the monsoons due to prevailing drought conditions around the year. But due to NICRA project they diversified their crops according to availability of water. Many farmers built wells on their farms, and started dairy and poultry farming for additional income. Under NICRA project, five Khadknath breed of poultry was given to each farmer in the village especially women farmers. A custom hire centre was established in each village to provide farm implements to the farmers. In-situ conservation of water was also done for ground water recharge. Farmers started working in groups which enhanced their decision-making capacity or teamwork. Farmers learned to do collective farming.

Timely weather-related information and crop advisories were provided on the basis of local weather conditions. Farmers started growing the crops on the basis of advisories provided by NICE platform. Timely weather information through posters in cooperative dairy centre or SMS helped with better planning of crops resulting in better yields. It also increased the decision-making ability of farmers, which is important to deal with the changing climate. Farmers also diversified their source of income by taking up dairy or poultry farming under this project. Some farmers grew capsicum in the polyhouse condition. A soil moisture-metre was also given to farmers who established polyhouses so that they could measure the soil moisture first and then apply water to the crops. Various farmers groups were formed in the village which enhanced the farmers' decision-making capacity, risk-taking ability, etc. It was observed from the study that many farmers implemented two to three practices simultaneously, like use of mulching, bio-organic slurry, polyhouse cultivation etc. to cope with the adverse effects of climate change. It indicates that CSA investments need to refer to technological packages, rather than isolated solutions. Some farmers, though, said that sometimes the prediction of NICE platform is not accurate according to the local weather because there is no automated weather station in the village.

Case study: Use of bio-organic slurry for pomegranate cultivation in climate-stressed condition

In CCKN-adopted villages, pomegranate is being cultivated in large areas. Most of the farmers cultivated pomegranate on light-to-medium soils having less organic carbon (0.20-0.50%) with poor water-holding capacity. In summer, due to high temperatures there is loss of high amount of organic carbon from the soil. The soil organic carbon plays a vital role to improve of the physical, biological and chemical properties of soil. Less organic carbon leading to poor white root development affects soil moisture storage and nutrients uptake in the plant. Under such circumstances, application of bio-organic slurry prepared from cow dung, cow urine, jaggery, pulse flour and various beneficial microorganisms are found very effective for improvement of soil organic carbon and water-holding capacity of the soil near the root zone of plant causing sufficient white root development. Under CCKN project, KVK made an intervention by undertaking the bio-organic slurry application for pomegranate as a pilot project to enhance the soil organic carbon, promote the white root development and nutrients availability and uptake. The activities like trainings, group meetings, demonstrations, field visits have been undertaken by the KVK to create the awareness as well as to promote the adoption of the technology. KVK selected 30 pomegranate farmers for the demonstration purpose in five CCKN project adopted villages Pimprilokai, Gogalgaon, Khadkewake, Kelwad, Korhale and Walki. Under this project, bio-fertilizers and bio-pesticides are supplied to the farmers. The soil organic carbon, nutrients uptake data, number of fruits/plant and average fruit weights are recorded for study. The yield and economics data were also collected. Result of this trial showed that bio-organic slurry helps to improve the soil pH and organic carbon. Increase in leaf N, P, K and chlorophyll by 8.12%, 23.08%, 9.0% and 18.46% was also recorded. Yield increased by 10.58 saving costs on fertilisers and pesticide by Rs.10283/acre.

(**Source-** CCKN IA, 2016)

Summary

Table 5: Summary of the findings

S. No	Type of methods	Operational description	Who uses it	Strengths	Weakness
1.	Climate Awareness programmes/ Campaigns, Exhibitions,	• It is used to sensitise the people about climate change, its consequences and effects on farming. • Introduction about the different activities of the project	CCA NICRA CCKN-IA	• Timeliness or frequency of information delivered	Take much time and efforts.
2.	Climate work-shops	• Awareness creation for use of SRI method of rice cultivation, preparation of crop plan for the season, water budgeting to know the availability of water, resource mapping, promotion of poultry & goat farming particularly for women income generation. • Persuade farmers in adoption of technologies (SRI method of rice cultivation, preparation of crop plan for the season, water budgeting, resource mapping, promotion of poultry and goat farming particularly for women)	CCA NICRA CCKN-IA	• Sensitise farmers about different components and activities of the project	Less participation of women farmers
3.	Climate Trainings	• Provide various adaptation and mitigation practices to the farmers and to develop their skills trainings of field extension worker is also done to make them familiar about the project and its activities. • Extension agents trained and provided tablet applications for effective and timely dissemination of advisories.	CCA NICRA CCKN-IA	• Skill building in farmers to identify and successfully use the climate-resilient livelihoods or adaptation & mitigation strategies	All the time farmers expect that they will get some free incentives
4.	Climate Farmers field schools (FFS),	• Climate-smart location specific interventions like use of drought-resistant variety, use of mulching, cultivation of less water intensive crop, goat and poultry raring, polyhouse cultivation was promoted.	CCA NICRA	• Motivate the farmers to adapt the climate smart technologies	Some socio-cultural issues like caste system

5.	Field visits to progressive farmers,	• Visits progressive farmer's field that were using different adaptation practices like who were using in-situ moisture conservation technique, mulching, integrating farming system, doing polyhouse cultivation.	CCA NICRA CCKN-IA	• Sensitise the farmers & promote them to make use of various climate smart adaptation or mitigation strategies. • farmers were motivated to adopt these practices in their fields	Farmers were reluctant to go to the progressive farmer of their own village.
6.	Demonstration on different adaptation or mitigation practices,	• Method demonstration was conducted on the farmers field so that they get to know about the method of that particular practice like SRI of rice crop, preparation of organic slurry to improve the soil pH and organic carbon, in situ soil moisture conservation, mulching, use of water lock chemical, silage making etc.	CCA NICRA CCKN-IA	• Shows the actual adaptability of the technology in the real field situation or real climatic conditions.	• Less demonstration as per the requirement or area of farmers. • 100% adaption was not there.
7.	Dissemination of appropriate climate resilient technology such as portable soil testing kits, farm mechanization equipment for small holdings, grain storage bags, improved crop varieties etc), irrigation management	• Promotion of zero tillage • Use of pheromone trap • Various farm implements were given to the different farmers in group like grass cutter, tiller, harrow etc. • Custom hire centre was established in the village to prove mechanical support to the farmers. • Some drought tolerance varieties of sorghum, bajra or rice was given to the farmers. • Hybrid breed of poultry vanraja, shrinidhi or khadaknath were distributed among the women farmers for income generation.	CCA NICRA CCKN-IA	• Promote the use of latest technology, use of resistant varieties or irrigation methods etc.	• Farmers did not adopt the paid technologies.

		• Bhagava variety of pomegranate and PKM 1 variety of drumstick were given to the farmers of Gogalgaon or Pimprilokai village of Rahata block under CCKN- IA project			
8.	ICT supported network	• It was a important tool used in CSA • NICE Plate-form • Uses of mobile phone for SMS	CCA NICRA CCKN-IA	• Takes very less time to contact large number of peoples in a very short period of time. • It save the time of both service provider or farmers. • Very useful in critical weather condition to make farmers alert.	Most of the women farmers does not have mobile phones. In some villages there were network problem.
9.	Participatory crop planning,	• It is done with the help of farmers. Contingency crop plans are technical documents containing integrated information on agriculture and allied sectors i.e., horticulture, livestock, poultry, fisheries and technological solutions for all the major weather related aberrations including extreme events viz., droughts, floods, heat wave, cold wave, untimely and high intensity rainfall, frost, hailstorms, pest and disease outbreaks.	CCA NICRA	• Guides the farmers in their crop planning process. • Help farmers to grow the crops according to climatic condition. • Decreases the chances of crop failure hence enhance the farmer's income.	Follow up is not there All the farmers does not follow it. Little bit variation is there according to the real field situation.

10.	Jaldoot - community level extension professional	He acts as a local extension worker which has knowledge on all water related activities. He helped the farmers in different activities involved in water budgeting, construction of water ponds, bore wells, etc. Helped the farmers mainly in planning their crops according to water availability.	CCA	• To sensitise the farmers about the needs to better manage the available water and use it efficiently. • Helps in entire process of water budgeting.	Single Jaldoot have to cover large area.

Recommendations

- **Need for extension reforms –** For the long-term process of reforming and strengthening rural advisory systems, some immediate priority actions for developing climate-smart rural advisory systems and services include: establishing local-level platforms/mechanisms for better alignment and collaboration between public sector advisory services working on agriculture, water, environment, forestry, fisheries and livestock; strengthening the capacities of RAS and other stakeholders to support innovation processes at organisational and individual levels; and improving the capacity of service providers to identify and use a range of extension methods and approaches appropriately for sharing CSA technologies and practices with farmers.
- **Need for a gender-specific approach-** An inclusive approach to CSA is needed, one that both empowers women and generally reflects differing gender roles, and deliberately aims to involve rural youth. An 'innovation system' approach should be taken that encompasses not only the introduction of new technologies, but also organisational and behavioural changes. Men and women access climate information differently. It was found that only men have mobile phones, a deliberate effort to put at least one phone in the hands of a woman in each village resulted in more climate and weather information being available to the entire village. When both men and women had access to the same information, they could jointly decide how to prioritise planting of their respective fields and not assume that the men's fields would be planted first. Hybridisation of communication methods (McOmber, et al., 2013) is the best way to ensure that women farmers are reached:
- Use of ICTs should be promoted to deal with the climate change.
- Training or retraining of the extension staff to acquire new capacity in climate change management.
- Identification and validation of Indigenous Technical Knowledge (ITKs)
- Promote farmer-to-farmer extension linkage for climate-smart information delivery.
- Need to cover more number of farmers under the projects.
- Need to sensitise them more about the emerging issue of climate change.
- Need to increase the number of working extension worker in the working area.
- Need to add on the women extension worker to focus more on women's participation in different activities.
- Need to promote more climate-smart extension approaches like development of CSVs, Plant clinics, appointment of 'monsoon manager' at village level etc.

Conclusion

Extension services play a key role in CSA because of their role in knowledge transfer to farmers' fields. The correct mix of different extension approaches used in CSA will largely depend on factors such as: the complexity of extension messages, the target population and its geographical spread, the available technology, the type and variety of data to be collected from farmers, and lastly, on the financial means available for extension. On-the-ground implementation of extension also needs to go hand-in-hand with advocacy and awareness raising of decision makers on the imminent threat of climate change for agriculture in order to make extension more responsive to climate change and contribute to address the triple challenge of food security, adaptation and mitigation. It was found that extension approaches with two-way information flow are particularly valuable to address climate change adaptation because they collect real-time agricultural information and are able to detect effects of climate change on a local scale that can be used for decision makers to react to threats to agriculture. There are a number of agricultural practices and technologies that enhance food security, resilience, and productivity in a sustainable manner. These include on-farm practices such as those relating to management of soil, water, crops, livestock, forests and fisheries, as well as beyond farm interventions such as agricultural extension systems, meteorological services, and crop and livestock insurance. The agricultural sector has rich experience in designing and implementing agricultural practices and technologies, drawing upon both scientific and indigenous knowledge (Cerdan et al., 2012). This means that designing context-specific interventions is achievable; however, strong mechanisms for capacity enhancement and technology transfer are prerequisites for success. It was found that many climate-smart extension methods have been successful because of availability and access to funding. Scaling up of agricultural adaptation and mitigation practices and technologies will only be feasible if farmers have accurate climate-smart information. That, in turn, is possible when suitable sources of funding are available. Funding can be in the form of international climate finance, but also national development finance and private sector investments, strategically programmed to achieve multiple objectives. Also, an imbalance in number of male and female extension workers poses problems in rural areas as rural women, due to socio-cultural barriers, find it difficult to effectively communicate with male extension personnel and consequently, get left out of the benefits they provide since women and men farmers have different levels of access to assets, time, resources, and different needs and priorities. An approach which addresses women's interests, resources and demands is highly beneficial. This can be done by recognizing and supporting women as innovators, capable of developing new technologies and adapting existing ones to meet their needs (Huyer et al., 2015). It was observed that strong mechanisms for finance, capacity development and technology transfer are prerequisites for the success of various adaptation and mitigation practices and technologies used in climate-smart agriculture.

In this paper, some extension methods and approaches were identified in Maharashtra region which have been implemented but there are many more which need to be implemented to make the farmers more climate smart. Therefore, climate-smart extension approaches need to be considered as part of a broader set of adaptation measures and policies for agricultural systems at a range of

scales. Climate change is an ongoing phenomenon, thus the objective of the project was not to find any one solution but first to develop communities and groups of farmers into active researchers. Then this active research and exchange of knowledge and experience on different levels has created a sort of climate resilience tool box that can be dipped into to try and test and adapt in new situations. So, CSA policies should promote both practices and services, such as financial services (crop insurance, subsidies, credits, etc.) and strategies for knowledge sharing and management (strengthening of extension services, early warning system, etc.).

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