Extension and Advisory Services for Climate-Smart Agriculture

13

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Abstract

Climate is turning out to be a prominent issue of concern nowadays. Climate change is the changing statistical distribution of the patterns that continues over years typically decades or longer. This climate change amplifies the threats like hunger, malnutrition, diseases, and poverty, thus affecting the progress of the world. Agriculture is the most vulnerable sector affected by climate change as it is highly dependent on local climatic parameters, such as rainfall, temperature, and soil health. It is the major driver of climate change. There is a high need to prevent the agriculture sector from being a prey to this climate change. It is time for agriculture to be "climate smart" for sustainably achieving the productivity and incomes and reducing the greenhouse emissions, wherever possible and to be resilient to climate change. Climate-smart agriculture (CSA) is an integrated approach that can address several challenges interlinked with climate change. This concept now has a wide ownership among the national and international agencies, government, and civil societies with a strong focus. Though CSA has been gaining importance, its dissemination and uptake of climate-smart technologies, tools, and practices are still largely an ongoing and challenging process. The adaptation of climate-related knowledge, technologies, and practices based on regional requirements, promoting a coordinated learning by farmers, researchers, extension workers, and the wide dissemination of CSA practices, is possible through the extension to an extent. Extension and advisory services can bridge the knowledge gap by providing clarity on CSA components and its relevant issues. They also play a vital role in helping farmers to cope with the diverse impacts of climate change by creating awareness by using appropriate tools to make them aware about different adaptation and mitigation strategies. This chapter provides a detailed description of how this rural advisory services

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and extension systems aid in climate-smart agriculture. The novel extension approaches like the information and communication technology (ICT)-enabled extension services and climate information services help the farmers at grass root level. The promising innovative extension approaches that are required to be adopted for the changing climate are enlisted to achieve CSA.

Keywords

Climate-smart agriculture · Innovative extension approaches · Advisory services

13.1 Introduction

Agriculture is the most sensitive sector affected by short-time changes in weather and to seasonal, annual, and long-term variations in climate. "It is vulnerable to climate change because of its dependency on local climate parameters like rainfall, temperature, soil health, etc." (Rupan et al. 2018). Climate change affects agricultural productivity in two ways: first, directly due to changes in temperature, precipitation, and/or CO_2 levels; and second, indirectly through changes in soil, pest damages, and disease infestation. "Impact of climate change on agriculture will be one of the major factors influencing the future food security as it shows visible effects on major crops like rice, wheat and maize" (Saravanan et al. 2018). "The estimated impact of both historical and future climate change on cereal crop yields in different regions indicate that the yield loss can be up to −35% for rice, −20% for wheat, −50% for sorghum, −13% for barley and −60% for maize depending on the location, future climate scenarios and projected year" (Porter et al. 2014; Saravanan et al. 2018).

In developing countries, agriculture continues to be the major source of employment, livelihood, and income. According to Food and Agriculture Organization (FAO) estimates for the year 2010, emissions from the agriculture, forestry, and other land use (AFLOU) sector directly accounted for 22% of total global emission (FAO 2016b). The impact of climate change which includes increasing temperature, shifting precipitation patterns, more severe weather events, loss of ecosystem, and biodiversity occurs from regional to the global level. If no urgent measures are taken, this will put millions of people at risk of hunger and poverty. It affects the rainfall, temperature, and humidity and is even a serious threat to the crop and livestock production. It leads to soil erosion, nitrogen leaching, reduction in crop diversity, land speculation, land renunciation, ocean acidification, ecosystems disruptions, and biodiversity loss. It also leads to decline in agricultural productivity, thus resulting in shortfalls in food supply and increase in food prices. "The overall agricultural productivity for the entire world is projected to decline between 3% and 16% by 2080 as a result of this climate change, hindering the overall food production" (Rupan et al. 2018).

Agricultural production and food systems should focus on sufficient utilization of natural resources and other agricultural inputs as a central element for making agriculture climate smart to overcome the decline in agricultural productivity.

"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" (Rupan et al. 2018). To attenuate some of the complex challenges posed by climate change, agriculture and its allied sectors have to become "climate smart," which avoids lose-lose situation by integrating climate change in agricultural strategies.

Climate-smart agriculture (CSA) may be defined "as an approach for transforming and reorienting agricultural development under the new realities of climate change" (Lipper et al. 2014). It is neither a new agricultural system, nor a set of practices. It is an innovative approach that integrates climate change into planning and development of sustainable agriculture systems.

CSA promotes new methods and technologies that contribute to raise in farm productivity, which in turn boosts up the farmers' profits. But, it needs a long-term coordinated efforts by all the stakeholders in order to make the transition to climate-smart agriculture. The agricultural producers should play a key role in adopting the CSA practices in order to build up their capacity to face the odds and contribute to sustainable development. Despite the various benefits of CSA technologies, the current rate of adoption by farmers is fairly low (Palaniswami et al. 2015).

Strengthening the capacity of farmers to manage risk and adopt effective climate change adaptation and mitigation strategies is, therefore, essential to cope up with changing climatic conditions. "The implementation of CSA would involve changes in the behavior, strategies and agricultural practices of millions of farmer's across the world to follow the principles of sustainable food and agriculture" (Saravanan et al. 2018). Farmers need to understand the impacts of climate change and develop resilience through climate-smart practices. "Rural Advisory Services (RAS) have a crucial role to play in linking farmers with the sources of new information and tools so that they can transition to CSA practices" (Simpson and Burpee 2014; Saravanan et al. 2018).

The extension and advisory services (EAS) personnel, especially those working at the field level, are already engaged in their roles to overcome the menace of climate change. They have detailed understanding of the local vulnerability context, as well as of the existence of local support and service networks. Farmers are more receptive to EAS, and the personnel of EAS have also been supporting the mobilization of farmer's groups to collectively deal with natural resource management and significantly contributing to enhancing food security through promoting the CSA practices. In the context of RAS, it needs advise from researchers on appropriate technologies and practices adopted for climate change. It also includes policies, institutional arrangements, stakeholder involvement, infrastructure, and access to knowledge and support from a wider range of other organizations that are crucial for their effective functioning, especially in promoting CSA.

There is also a need for strong extension network and location-specific innovative extension approaches to handle the complexity of achieving CSA. A higher level of institutional commitment to promote CSA and strengthen pluralistic RAS will be needed to enhance the contribution of the extension systems to CSA. It is essential to improve the capabilities of service providers and stakeholders "to identify and use a

range of extension approaches for sharing appropriate CSA technologies with farmers" (Rupan et al. 2018). There is an urgency to explore, conceptualize, and change agricultural extension to cope up, adapt, and combat the risks associated with the changing climate. Thus, there is an alarming need for the paradigm shift in the extension systems to be adapted by the farmers to mitigate the climate change.

13.2 Climate Change and Agriculture

Agriculture is the most important source of livelihood to the majority of the world's poor living in the rural areas and accounting for about a third of gross domestic product (GDP). Developing the potential to increase the productivity and incomes to the small crop holder is a first step to achieve the key goal of food security. The agricultural sector in addition to meeting the food and raw material needs of the world's population also provides a gainful employment to the rural masses.

Climate change will pose many unpredictable challenges to the agricultural sector as agricultural production is very closely interlinked with weather aberrations. Mounting evidence points to the fact that climate change is already affecting agriculture and food security, which will make the challenge of ending hunger, achieving food security, improving nutrition, and promoting sustainable agriculture more difficult (FAO 2016a). Agricultural system has to become more efficient to mitigate these ill effects of climate change without compromising food and nutrition security.

"Climate change is projected to have significant impacts on conditions affecting agriculture, including temperature, carbon dioxide, glacial run off, precipitation and an interaction of all these elements. The overall effects of climate change on agriculture depends on the various measures adopted to balance these effects" (Rupan et al. 2018).

Effects of climate change in agriculture through several ways are as follows:

(a) Effect on productivity (in terms of both quality and quantity of crop)
(b) Effect on agricultural practices (changes in irrigation patterns and application of herbicides, fertilizers, and insecticides)
(c) Environmental effects (soil erosion, land speculation, land renunciation, and adaption)

13.3 Impact of Climate Change on World Agriculture

Climate change invariably affects the agricultural sector, and its impacts vary region to region across the world. As a result of climate change, the croplands may become unsuitable to crop production due to increase in the frequency and intensity of severe weather events. This directly affects the agricultural production, which in turn will have economic and social consequences thus reflecting in the prevalence of food insecurity. Indirectly, it affects the crop yields through soil erosion leading to land

degradation. Climate change will have negative impacts on all dimensions of food security (FAO 2016b; Venkatramanan and Shah 2020).

"The affected areas from climate change are economically vulnerable countries, already food insecure and some important food exporting countries. This will reduce 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" (Padgam 2009; Rupan et al. 2018).

The world agriculture also faces a serious threat in this century due to global warming and due to declined levels of production. "The agricultural productivity for the entire world is projected to decline between 3% and 16% 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 30–40%" (Mahato 2014; Rupan et al. 2018).

World Bank noted that almost half of the South Asian population (800 million South Asians to be exact) are at risk to see their standards of living and incomes declining as rising temperatures and more erratic rainfalls will cut down crop yields, make water scarcer, and push more people away from their homes to seek safer places. Productivity decline leading to food supply shortfalls and increase in food prices would directly affect millions of low-income smallholder farmers, especially those who depend on agriculture for their livelihood and income in South Asia (World Bank 2018).

13.4 Climate-Smart Agriculture (CSA)

FAO introduced the concept of "climate-smart agriculture" in the background document prepared for the 2010 Hague conference on agriculture, food security, and climate change. There has been a growing support for this approach at both international and national levels. CSA helps to achieve higher production with reduced emissions. This would have been a simple answer to climate change, if its impacts are less and simple. The small farmers are facing a plethora of problems like nonclimatic stresses and have limited capacity to adopt new technologies. CSA aims at developing agricultural strategies, thus enabling the stakeholders at all levels to attain sustainable food security under climate change. The Food and Agriculture Organization defined CSA as "agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces greenhouse gasses (GHG's) where possible and enhances achievement of National food security and development goals" (FAO 2013). The three interlinked pillars in achieving the goal of food security and development in CSA are productivity, adaptation, and mitigation. "The agricultural production system requires resilient development pathways to augment global food grain production, reduce greenhouse gases emissions from agricultural activity and

adapt agriculture to climate change and variability" (Venkatramanan and Shah 2019).

Stepping up and facing many challenges in agriculture is not easy. However, the solution may lie in CSA. It is an integrative approach to address the challenges of food security and climate change that explicitly aims for the following objectives:

- "Sustainably increasing agricultural productivity and incomes
- Adapting and building resilience to climate change at various levels
- Reduce and/or remove greenhouse gas emissions from agriculture and allied sectors"

Achieving these objectives of climate-smart agriculture requires changes in the behavior, strategies, and agricultural practices of farming households.

The key characteristics of CSA include the following:

- Addresses the climate change
- Integrates multiple goals and manages trade-offs
- Maintains ecosystem services
- Has multiple entry points at different levels
- Context specific
- Engages women and marginalized groups

13.4.1 Elements of CSA

CSA approach includes "different elements embedded in local contexts (both on farm and beyond the farm) and incorporates technologies, policies, institutions and investments" (Fig. 13.1) (Saravanan et al. 2018). CSA addresses food security, misdistribution, and malnutrition; it addresses the relationship between agriculture and poverty; and it also addresses the relation between climate change and agriculture. The elements which can be integrated in climate-smart agricultural approaches include the following:

- Management of agricultural farms, various crops, livestock, aquaculture, and capture fisheries to balance near-term food security and livelihoods' needs with priorities for adaptation and mitigation.
- Ecosystem and landscape management to conserve ecosystem services for food security, adaptation, and mitigation.
- Services for farmers and land managers to enable them to implement the necessary changes.
- Changes in the wider food system and value chain interventions for CSA (Saravanan et al. 2018).

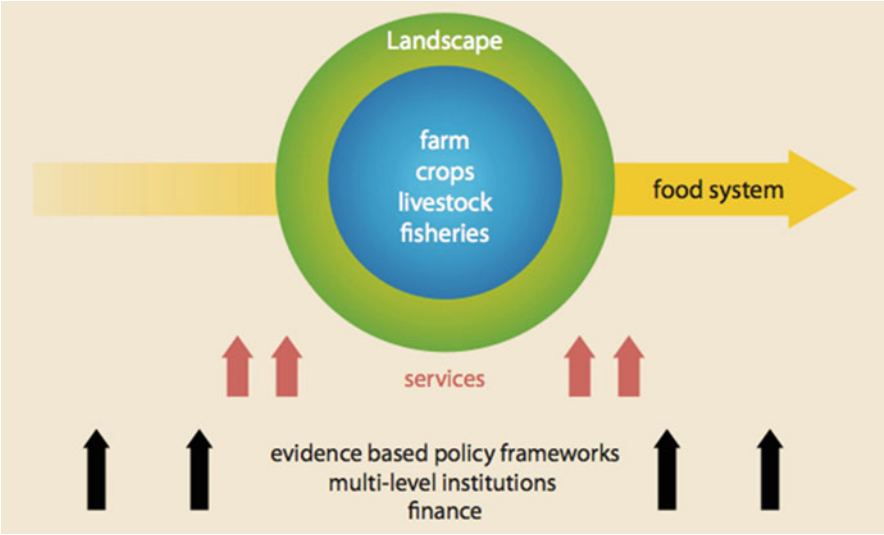

Fig. 13.1 Elements of CSA. (Source: https://ccafs.cgiar.org/climate-smart-agriculture-0#.WnqMM-hubIW)

13.4.2 Climate-Smart Agriculture Implementation in Agricultural Production and Food Systems

- *Climate-smart crop production*
  The harmful impacts of climate change on agricultural production can be subsided through adaptation and mitigation options that can sustainably improve the yields. Specific climate-smart approaches to crop production include the following:
  - Quality seed and planting materials tested under multilocational trails.
  - Crop varieties that are resistant to climate-related phenomenon like floods, droughts, etc.
  - Improving sustainable soil and land management for increased production.
  - Efficient utilization of natural resources.
  - Promoting sustainable mechanization and proper agronomic management.
  - Integrated Pest Management (IPM), Integrated Nutrient Management (INM), and improved water-use efficiency.
  - Biodiversity management.
  - Developing simple and robust scientific technologies for decision-making of agricultural producers on a seasonal and long-term basis.
- *Climate-smart livestock production*
  Though livestock contributes to higher greenhouse gas emissions, its vulnerability to climate change can be reduced through sustainable climate-smart practices with the mitigation potentials, with reduced emissions from manures, and by promoting carbon sequestration.

- *Climate-smart fisheries and aquaculture*
  Healthy ecosystem and sustainable use of aquaculture and fisheries resources are an essentiality for adaptation and mitigation of climate change. Strategies include reduced emissions, decrease overcapacity, and carbon imprint of trade in fish and fisheries products.
- *Integrated production systems*
  Supportive integration of mutually supportive and mutually dependent production systems such as agroforestry, crop–livestock, rice fish, fish–livestock, and food energy systems, as well as less widespread systems, like aquaponics, offers farmers to mitigate risk and also to adapt to the impacts of climate change.
- *Sustainable soil, land, and water management for climate-smart agriculture*
- *Sustainable use of genetic resources for CSA*
- *Developing sustainable food systems and value chains for CSA*

13.4.3 Policies for Climate-Smart Agriculture

As the climate-smart agriculture is gaining prominence in the development of communities, organizations, research institutions, etc., various adaptation practices for building resilience to climate change and weather variability will contribute to climate change mitigation. Those options are needed to be enabled and supported by appropriate policies, institutional frameworks, and investment finance mechanisms. There is a need to design a national climate-smart agriculture approach with coordination among various stakeholders like the agricultural producers, private sector, and large- and small-scale enterprise holders involved in food value chain (Box 13.1). An enabling policy and framework with support from government at various levels, involving the private sector for scaling up of CSA can trigger the agricultural production and the food systems (Fig. 13.2). The rural agricultural extension and research institutions should also be a part of policy making, generation, and dissemination of climate-smart agriculture.

Box 13.1 Stakeholder Analysis and Adoption Determinants of Climate-Smart Agriculture

Deepika et al. (2018) in their study "Climate smart agriculture towards triple win: adaptation, mitigation and food security" revealed the mixed results of the stakeholder analysis working under the CSA programs (irrigation projects, diversification projects, and insurance schemes) and the adoption determinants, that is, barriers and incentives while adopting these CSA practices.
The findings clearly proved that the stakeholders viz., government institutions (SAU and ZRS), state department of agriculture and the other line departments, research institutions (KVK), development officers (ADOs and AEOs), extension officers (AEOs and VLWs), farmers' associations, self-help groups, input dealers and traders, NGOs, and Krishak Vikas associations have been involved either directly or indirectly to develop, plan, execute, implement, and manage all the activities of CSA programs. The activities such as exposure visits, demonstrations, and trainings on method of doing all the CSA practices

(continued)

Box 13.1 (continued)

have been organized for the farmers through different programs.
It is also concluded from the study that the actor-linkage matrix of the state- and district-level stakeholders has strong relation among themselves in development, formulation, implementation, and evaluation of all the activities. CSA programs and also stakeholders at various levels have strong relation among themselves in identifying and solving the problems of weather variability in the target area. The services like distribution of inputs and organizing extension activities have been provided to farmers under the CSA programs for adaptation and mitigation of climate change effects. Monitoring and evaluation of all the CSA activities and proceedings have been done by the implementing agency in collaboration with SAUs, ZRS, ATARI, etc.
Agro-advisory services viz., sowing time, irrigation time, availability of inputs, and weather forecasting messages have been given to the beneficiaries through m-kisan portal, a personal contact method by extension officers, mobile, newspapers, progressive farmers, neighbors, etc. Lack of interest among farmers and labor unavailability have been identified as barriers in adopting the CSA practices.

Source: Deepika, Suchiradipta, B., and Saravanan, R. 2018. Climate-smart agriculture towards triple win: adaptation, mitigation and food security. MANAGE Discussion Paper 5, MANAGE-Centre for Agricultural Extension Innovations, Reforms and Agripreneurship (CAEIRA), National Institute of Agricultural Extension Management, Hyderabad, India

Many countries proposed policy actions in relation to agriculture and land use in their "Intended Nationally Determined Contributions" (INDCs) under the "United Nations Framework Convention on Climate Change" (UNFCCC). As of 31st March 2016, INDCs had been submitted to the UNFCCC by 188 countries. Under the

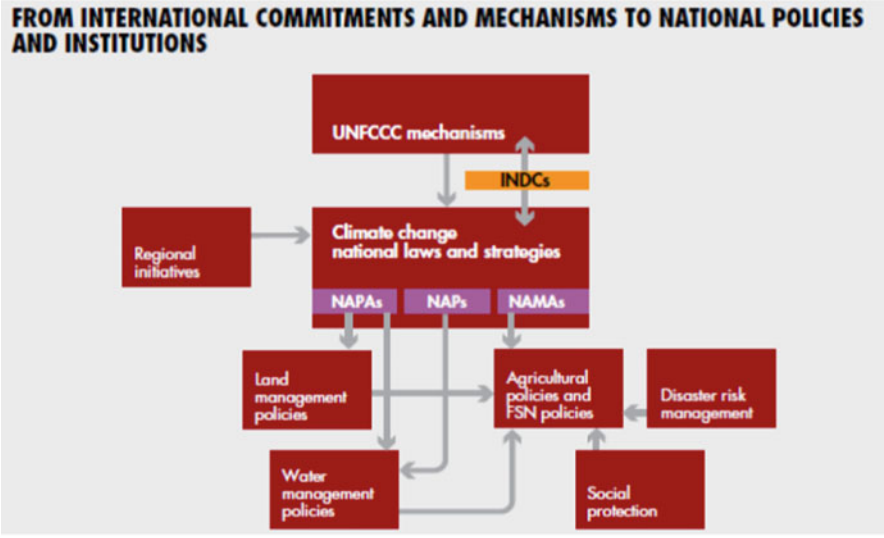

Fig. 13.2 Climate change policies and strategies. (Source: FAO 2016a)

UNFCCC, a series of instruments have been designed for linking International Climate Change commitments to concrete action for mitigation and adaptation at the national level viz., "National Adaptation Programmes of Action" (NAPAs), "National Adaptation Plans" (NAPs), and "National Appropriate Mitigation Actions" (NAMAs) (Heltberg and Bonch-Osmolovskiy 2011; Lipper et al. 2014; Meinzen-Dick et al. 2012; Nelson et al. 2010; Mutoko et al. 2015). These instruments focus on adaptation or mitigation measures to attain CSA. To mainstream the climate change and its impacts, there is also a need for greater coherence, co-ordination, and integration among various sectors at national level.

In 2011, the "Consultative Group on International Agricultural Research" (CGIAR) approved research program on "Climate Change, Agriculture and food security" (CCAFS), one of the biggest CGIAR research programs on climate change. The CCAFS also works at a global level by Global Alliance on Climate Smart Agriculture (GACSA), a multistakeholder platform on CSA aids in strengthening the influence of region in global spheres. It plays a key role in fostering knowledge, partnership building, space for dialog, and debate. The CCAFS working in concert with programs that promote CSA, including the GACSA, is supported by some multilateral organizations, donors, players from the private sector, and other stakeholders. CCAFS sees its alignment with GACSA as a way to act collaboratively to promote "an overarching global framework for CSA investment" (Deepika et al. 2018).

13.5 Role of Extension and Rural Advisory Services (RAS) in Climate Change Adaptation

The Global Forum for Rural Advisory Services (GFRAS) defines RAS as "all the different activities that provide the information and services needed and demanded by farmers and other actors in rural settings to assist them in developing their own technical, organizational and management skills and practices so as to improve their livelihoods and well-being" (Christoplos 2010). The extension agents, community knowledge workers, agronomists, facilitators, advisors, promoters, knowledge intermediaries, and program managers act as the service providers of RAS. They deliver a wide range of services and provide technical managerial support to rural communities.

The scenario of extension systems has undergone changes over the past two decades, and it has evolved and enabled its services to rural communities through its activities such as sharing of technology and information; farm-related advices, organizational and business management; facilitation and brokerage in rural development; and value chains. The RAS delivery involves the participation of private sector, international and local nongovernmental organizations (NGOs); farmer groups, cooperatives, and associates; consultants, either acting independently or in association with agribusinesses and producer associations; and services thus increasing the pluralism.

RAS provides assistance to the producers and farmers' organizations to collectively deal with the natural resource management and also marketing challenges. It increases productivity of farmers by enhancing farming practices among individual farmers through collaborative agricultural and institutional innovation with farmers, researchers, and other groups. It facilitates the establishment of groups and associations of farmers to support promotion of new technologies (e.g., Farmer Interest Groups); enhance capabilities to deal with pests and disease management (e.g., Farmer Field Schools); manage natural resources; and engage in collective marketing.

Farmers nowadays confront several new challenges, such as sustaining yields under deteriorating and declining soil and water availability; coping with fluctuating demand and prices for their produce; adapting to climate change; responding to new products and quality standards; and attracting and retaining youth in agriculture. Though the government is making out policies and schemes to help the farmers overcome these problems, the groundwork of educating the farmers to respond is a challenge, which is taken up by the RAS. In order to achieve this, the RAS needs to broaden their mandate and work with many of the other stakeholders and service providers in the agri-food system. This also involves strengthening the capabilities of RAS providers and their organizations at varying levels (individual, organizational, and enabling environment level) as articulated in the GFRAS Position Paper, "The New Extensionist" (GFRAS 2014).

"RAS is playing a crucial role in achieving Climate Smart Agriculture by disseminating climate information and technologies and also information on production practices for climate adaptation through innovative approaches, such as plant clinics and participatory video (Digital green, etc.)" (Rupan et al. 2018). RAS is actively involved in promoting CSA among millions of farmers, and no other groups other than RAS providers can have an explicit focus on prerequisite changes and innovations among rural communities to enhance their livelihoods. But still, RAS needs to improve their effectiveness and capacity development at both individual and organizational levels with institutional reforms at the system level to achieve CSA.

13.5.1 Sustainably Increasing Productivity and Enhancing Adaptation Through Technology Dissemination

Extension from its methodology of technology transfer has shifted to working with farmers, developing the technologies that facilitates farmers and also is catalyzing the process of innovation. It has shifted its focus from the site–specific emphasis of farmer's needs to address the climate change. Extension providers have identified the need for the identification and assessment of the suitable agricultural technologies and practices needed for CSA and impart these technologies and methods through a participatory approach.

RAS plays a crucial role in dissemination of technologies, information, and practices through a wide range of extension methods, but at the point of CSA,

RAS providers face several challenges and, however, disseminate climate-resilient technologies. The RAS advisors seek to have more involvement and outlook to design the technical solutions for adapting to climate change by boosting agricultural productivity sustainably. In order to attain this, RAS providers will need to acquire new skills and improve the capacities along with the required institutional changes. The researchers and extensionists should develop closer linkages and work together hand to hand, which is now in a critical situation, as the researchers have no clear understanding of the location–specific farmer's needs and problems. There is a lack of proper feedback mechanism on how the technological interventions put forth into the farming community are working at the field conditions or they need adjustments according to the farmer's local needs. The researchers need to tap the local knowledge in order to provide the context-based location–specific advices for CSA. They need the assistance from the RAS providers for serving this purpose as they work close with the farming community and they act as the channel between the researchers and farmers.

The RAS providers also need to extend their focus beyond technology transfer to working at other levels for the overall benefit of the farmers, that is, helping them from overcoming the adverse effects of CSA along with raising their farm productivity and income levels. A unified extension system along with the intervention of the private sector aids in achieving the goals of CSA.

13.5.2 Building Resilience Through Developing Farmers Human and Social Capacity and Providing Support Services

Diversification of agriculture and income plays a crucial role in managing the risks and uncertainties associated with climate change, and farmers need to have sound local scientific knowledge, enhance their observational skills, and have critical thinking, problem solving, and decision-making skills about the appropriate practices and resilient income opportunities from a bundle of options. "RAS uses nonformal 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 abilities to encourage uptake and decision–making regarding knowledge intensive agricultural practices" (Braun et al. 2000; Waddington and White 2014; Rupan et al. 2018).

"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 building resilience will typically require new skills and capabilities at the organizational and individual levels" (Rupan et al. 2018). Rural advisors need to improve their soft skills and other specialized skills like marketing.

13.5.3 Supporting Climate Change Adaptation and Mitigation Through Facilitation and Brokering

Presently, RAS providers support to the Agricultural Innovation Systems (AIS) by playing various roles in the establishment of multistakeholder innovation platforms. These include acting as the main innovation broker, functioning as a "bridging organization facilitating access to information, knowledge and expertise, and providing technical back stopping" (Sulaiman and Devis 2012). Network building and brokerage, process facilitation, and monitoring are the key areas where the RAS and extension workers need to work in support with the farmers.

13.5.4 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. RASs are uniquely placed to highlight the outcomes of climate-related events to the policy makers and advocate for policy change and investment in CSA (Pralle 2009). Rural advisories can also play a role in explaining climate change policies to rural communities (Rupan et al. 2018). The rural advisors and the extension can help the farmers in creating awareness among the farmers regarding the policies for climate change by imparting them with the related knowledge. They can also help the policy makers through a proper feedback system regarding the farmer's awareness level perception, attitude, and vulnerability to climate change.

13.6 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. 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" (Rupan et al. 2018).

GFRAS (2014) argues that addressing the current global challenges requires the use of new knowledge which involves interaction and support from a wide range of organizations. To confront with the new challenges of climate change, "the extension systems need to tackle a diversity of objectives and go well beyond, transferring new technology. This encompasses the need to link more effectively and responsively to domestic and International market (food, feed, fibers, etc. and/or carbon); reduce the vulnerability and enhance the voice of the rural poor; promote environmental conservation; build linkages between farmer's and other agencies and institutional and organizational development to support the bargaining position of farmers by, for example, forming farmer groups" (Davis 2006; Rupan et al. 2018).

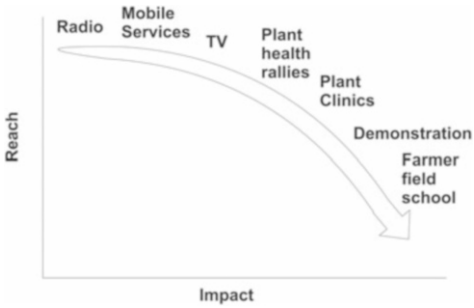

Fig. 13.3 Impact of extension approaches. (Source: Sala et al. 2016)

The new extensionists have, therefore, mutated from a production–centered role to an organized–integrated cross–sectorial function of the extension ecosystem. But the main posing question to all the extension systems is how best to respond to the climate change.

"Several ways have been found where 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 farmer's fields. In addition, reach and impact potential, two negatively correlated indicators, are of primary importance and differ between extension approaches, that is, generally, the higher the reach, smaller is the impact and vice versa" (Rupan et al. 2018).

Choice of approach combinations can influence the ability of extension services to contribute to CSA (Fig. 13.3; Box 13.2).

Box 13.2 Innovative Extension Approaches for Climate-Smart Agriculture

Rupan et al. (2018) in their study on "Climate smart agriculture and advisory services: approaches and implications for future" mentioned some of the innovative extension approaches for climate-smart agriculture in "National Innovations on Climate Resilient Agriculture" (NICRA), "Climate Change Knowledge Network in Indian Agriculture" (CCKN-IA), and CCA project. The extension methods for transfer of climate knowledge were SMS or Smart Messaging Services, Climate Wall Papers, Climate Voice Messages, Folk Media, use of Public Addressing System, Climate Group Meetings, Exposure Visits, and Climate Workshops. The extension methods for learning include Climate Field Group Visits, Farmer Interest Groups, Climate Trainings, Crop Calendar, Livestock Calendar, Block Contingency Planning, and Information and Communication tools. The extension methods for capacity development were Climate Trainings, Climate Workshops, Field Demonstrations, Climate Smart Farmer Field Schools (CFFS), Weather-Based Insurance, Community-Based Disaster Management (CBDM) approach, Village-Level Customs Hiring Center (CHC), Jaldoot, Community-Level Extension Professional, and Agro-meteorological Advisory Services.

In this paper, some extension methods and approaches that were identified and implemented in Maharashtra region are enlisted, but there are many more which need to be implemented to make the farmer more climate smart. Therefore, climate-smart extension

(continued)

Box 13.2 (continued)

approaches need to be considered as part of a broader set of adaption measures and policies for agricultural systems at wider scales.

Source: Saravanan, R. Karthikeyan, S. and Vincent, A. 2018. Extension and advisory services for climate smart agriculture. *MANAGE Bulletin 3* (2018), National Institute of Agricultural Extension Management (MANAGE), Hyderabad, India

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

1. Climate awareness programs/campaigns and exhibitions
2. Climate trainings
3. Climate workshops
4. Plant health rallies
5. Climate farmer field schools
6. Field visits to progressive farmers
7. Demonstrations on different adaptation or mitigation practices
8. Plant clinics
9. Dissemination of appropriate climate-resilient technology
10. Information and Communication Technology (ICT)-supported network
11. Participatory crop planning
12. Appointment of climate manager at the village level
13. Appointment of the monsoon manager at the district level
14. Use of indigenous technical knowledge (ITKs)
15. Establishment of plant clinics
16. Climate-smart villages (Source: Rupan et al. 2018)

13.6.1 Climate Awareness Through Mass Media Campaigns

There is a high reach of mass extension campaign, as it can immensely influence a large mass of audience. However, the major constraints of extension systems are shortage of field extension personnel and limited resources to reach large numbers of farmers spread widely across the nation. The use of mass media can help to surpass these constraints. Extension with mass media campaigns run by nonextension players is more effective to drastically speed up the process of awareness 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; Rupan et al. 2018). It is, thus, an effective tool to present the national climate change adaptation strategies, challenges, experiences, and knowledge from local to national levels.

13.6.2 Climate Training

Training of intermediaries or extension personnel is important to update their knowledge related to climate change and to learn about how to solve the climate crisis together. As we know that climate-smart agriculture is a new and emerging issue, extension service providers should be familiar with meteorology terms. University education is the basis for any scientific education that supports the training in searching for solutions at extension level, for which science field crops were established (Stigter and Winarto 2013; Sala et al. 2016).

13.6.3 Plant Clinics

The plant clinics are "the frontline contact point of the National Extension System and also allow a 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 the plant health system" (Boa et al. 2015; Rupan et al. 2018). They vary in how they operate and the services they offer like some of the plant clinics have laboratory facilities for identifying pests and pathogens and some offer management advice through extension intermediaries.

13.6.4 Climate Farmer Field Schools (FFSs)

The Farmer Field School (FFS) is basically a participatory, nonformal extension approach based on experiential learning that puts farmers and their demands at center (FAO 2002). "It provides farmer 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; Rupan et al. 2018). "Climate Field School in Indonesia raised awareness of climate change and promoted solution 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; Rupan et al. 2018).

Farmer field school consists a group of 20–25 farmers, from the same community meet to engage in hands-on learning over an entire cropping season or natural production cycle. For crop-based FFS, activities may cover from "seed to seed"; in livestock–producing communities, they may deal with activities from "egg to egg" or "calf to calf." It builds up each individual participant's functional capacity to observe, analyze, communicate, and take informed decisions. FFS provides a platform to strengthen individual and community climate resilience, thus creating awareness among the farmers.

13.6.5 Plant Health Rally Approach

"It is an extension approach for quickly raising awareness about major agricultural risks or threats on important crops, to promote the use of improved agricultural practices and to collect the feedback from major issues which affect production. Plant health rallies are run by local extension workers. They are usually held in public spaces and are open to everybody" (Rupan et al. 2018). It can quickly raise awareness about major agricultural risk through targeted demonstrations and training sessions for promoting CSA approach.

13.6.6 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; Rupan et al. 2018). For example, The East Africa Dairy Development 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 (Rupan et al. 2018).

13.6.7 ICT-Supported Network

The term information and communication technologies (ICTs) is defined as the study of software application-based information systems (Information Technology Associations of America 2008). ICT can enhance and accelerate information sharing and exchange, collaboration, learning, training, collecting data, and monitoring. The primary objective of ICTs is to record data and information into knowledge and communicate it to common people. It plays a crucial role as an important source of information and communication in climate change awareness, adaptation, and mitigation strategies. "Farmer's ability to perceive climate change is a key precondition for their choice to adopt" (Gbetibouo 2008). "Use of mobile phones, videos, radios, etc. was done to address the issue of climate change by creating awareness among the farmers" (Rupan et al. 2018).

In developed countries, technology development is evident in all disciplines, for example, there is a rapid advancement and development of Mobile Technology (MT), Information and Communication Technology (ICT), and drones for climate monitoring, and this cannot be undervalued (Shafiq et al. 2014).

- Use of ICT for agro-advisory services in a climate-smart village in Nepal
- E-Arik—an innovative initiative in Arunachal Pradesh

- Participatory Integrated Climate Services for Agriculture (PICSA) approach in Africa
- Resilience Assessment Bench marking and Impact Toolkit (RABIT) (Saravanan et al. 2018)

List of widely used mobile application for generating awareness about climate change adaptation.

1. Climate change awareness
2. Global Warming Climate Change
3. MP Climate Change
4. Climate Change
5. Green IQ
6. WB Climate (World Bank)
7. Carbon Sins
8. Green Tips
9. Survive Global Climate Change
10. The Changing Climate Technovation (Chakraborty and Chakravarty 2017)

13.6.8 Climate-Smart Villages (CSVs)

CSVs are the developed villages or models of local actions built on the principles of CSA (Fig. 13.4). It has four main components:

1. Climate information services
2. Local knowledge and institutions
3. Village development plans
4. Climate-smart technology

The concept of CSV is being piloted in two Indian states, Bihar and Maharashtra, helping the farmers to cope up with climate change and providing training for hundreds of farmers in CSA technologies.

"The location of CSVs is selected based on its climate risk profile and the willingness of farmers and local governments to participate in the project" (Saravanan et al. 2018). Its focus is on blending local knowledge on conservation techniques with global perspective of climate change. "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 suits to the local conditions" (Rupan et al. 2018) (Fig. 13.5).

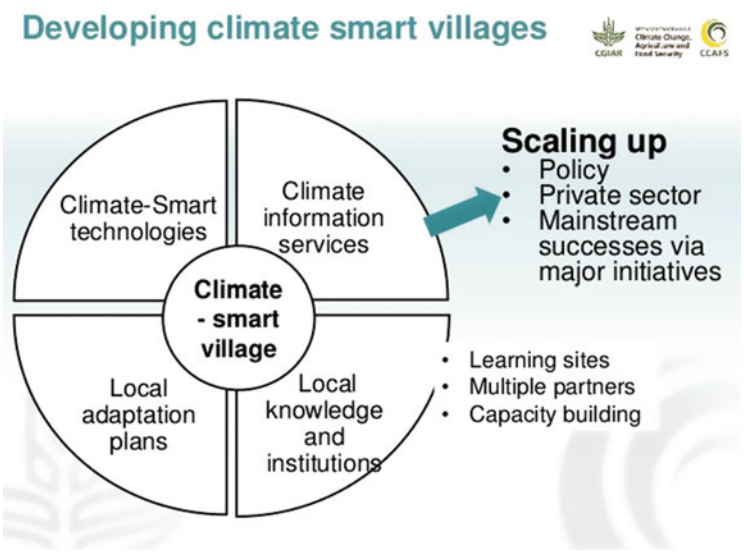

Fig. 13.4 Climate smart village. (Source: Zougmoré R., Ouédraogo M., Partey S., Bayala J., and Ky-Dembele C. (2015) "Towards climate-smart village models development: Current status and lessons learnt from West Africa." [PowerPoint Presentation]. Available at: https://www.slideshare.net/cgiarclimate/towards-climatesmart-village-models-development-current-status-and-lessons-learnt-from-west-africa (Accessed: 26 March 2020))

13.6.9 Training of Trainers' Approaches for CSA

The major categories extension approaches for CSA are group extension approach, the mass media extension approach, and the individual approach/household extension approach (Speranza 2010). The selection of an appropriate extension approach is determined by the target audience, the available resources, and the capacities of the facilitator, among other factors. Traditional extension methods within the mass media approach include the "use of radio, print media and audio visual aids. In the group extension approach, there are demonstrations of agricultural practices like field days, farmer's days, master farmer training, training workshops and meetings, study circles, exchange visits and farmer field schools. The individual extension approach involves house visits or individual farm visits" (Ngara 2017; Saravanan et al. 2018).

Different approaches, strategies, and methods are used in various projects to deal with the changing climatic conditions in the field situation or to help out farmers based on location/area. Information Communication Technology-based platform, knowledge informed, multidisciplinary and participatory approaches, etc. are some of the modern initiatives useful as an alert mechanism in this aspect.

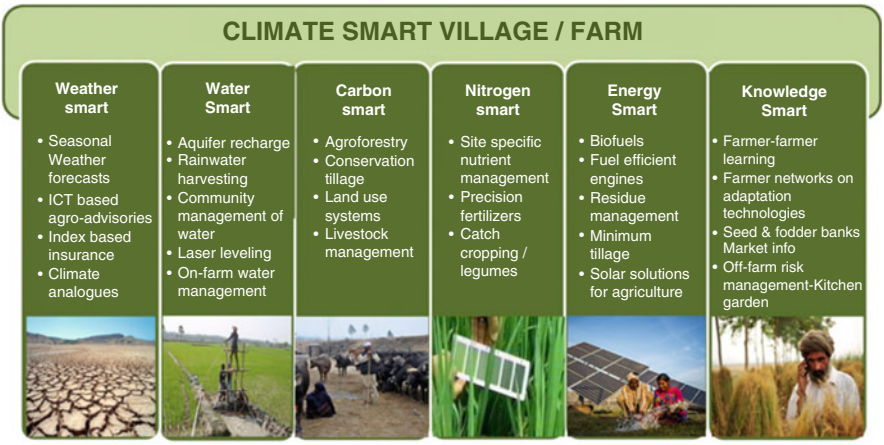

Fig. 13.5 Concept of climate smart village. (Source: Aggarwal PK., Khatri-Chettri A., Bhaskar SP., Jat ML., Joshi PK. (2015). "Climate-smart agriculture in South Asia: Opportunities and constraints in scaling out." [PowerPoint Presentation]. Available at: http://csa2015.cirad.fr/var/csa2015/storage/fckeditor/file/L1_2a%20Pramod%20Aggarwal.pdf (Accessed: 26 March 2020))

13.7 Social Media in CSA: An Innovative Approach to Adopt CSA

13.7.1 Facebook: Climate-Smart Agriculture

13.7.1.1 Climate-Smart Agriculture YOUTH Network (www.facebook.com/CSA.Youthnetwork)

"This group aims to raise awareness among youth regarding the upcoming threats related to climate change and to help them to make sustainable decisions so that they can contribute for a better future within agricultural sector by applying the CSA practices in agriculture and allied sectors" (Saravanan et al. 2018).

13.7.1.2 CGIAR Research Program on Climate Change (www.facebook.com/CGIARclimate)

"This mostly discusses about the best researches in agricultural sciences, climate science, environmental and social sciences to identify and address the most important interactions, synergies and trade-offs between climate change and agriculture. Thus this group is focused on recent studies related to climate change to overcome the threats of agriculture and food security" (Saravanan et al. 2018).

13.8 FAO Policy Support to Climate-Smart Agriculture

"FAO plays a key role in creating awareness on the importance of agriculture in achieving food security under the new realities of climate change and population pressure. Coordination and integration between various sectors dealing with climate change, population pressure, agricultural development and food security at international, national, regional and local level is a key requirement for creating an enabling policy environment. Providing incentives for adopting CSA, such as payments for environmental services, encourages farmers to take on climate-smart practices and to overcome initial investment barriers. FAO has identified two areas of intervention one is the policy support and the other include the planning for the adoption of climate-smart agriculture" (Saravanan et al. 2018).

FAOs program like "Economics and Policy Innovations for Climate-smart agriculture" (EPIC) works with the government's research centers, universities, and institutional partners to support the transition to climate-smart agriculture by using sound economic and policy analysis. It works on capturing the synergies between the three pillars of CSA (www.fao.org/climate-smart-agriculture/policies-planning/policy/en/).

13.9 CSA in African Policy Processes

"While the UNFCCC can establish the international policy framework for how agriculture is incorporated into future climate agreements, much policy development has to occur in national, regional and continental policy arena. NEPAD's comprehensive Africa Agriculture Development Program (CAADP) is the key arena for ensuring that climate change is mainstreamed into agricultural development. At the national level, adaptation plans and mitigation strategies are being prepared. Strategies to achieve and fully incorporate agricultural adaptation and mitigation into climate change strategies need more tangible, detailed measures that build on existing efforts and are calibrated to local conditions" (Saravanan et al. 2018).

13.10 Actions to Promote Upscaling of CSA Practices

The adoption of CSA practices usually requires "new forms of interactions, organization and agreement between multiple actors" (Leeuwis 2004). The upscaling of CSA practices involves a broad array of activities, as listed below:

(a) Convening (i.e., setting up platforms for stakeholder interaction and forming networks of strategic partners).
(b) Facilitating (dialog and the exchange of knowledge among operational partners)
(c) Organizing (joint events for implementing specific activities and setting up user/client groups).

(d) Training (farmers, knowledge intermediaries, and service providers from the public and private sector, civil society, and NGOs).
(e) Provisioning (of incentives, inputs, and infrastructure to encourage adoption and partnerships).
(f) Sharing knowledge (and experiences to hone policies and practices).
(g) Disseminating information (on new knowledge/practices/products through various media channels and person-to-person outreach).
(h) Undertaking adaptive research (through on-station and on-farm trails and participatory action research).
(i) Advocating (for policy recognition, greater public investments, and harmonization of laws and guidelines to accelerate the process of upscaling) (Sulaiman et al. 2018).

13.11 Implications for Agricultural Extension and Rural Advisory Services

"The crux of climate smart agriculture is to provide location specific climate smart technologies to the farmers" (Saravanan et al. 2018). Multiple stakeholders have to be involved in formulating the location-specific strategies and technologies.

1. The shift in the focus of extension has to shift from transforming skills, technologies, and knowledge related to crop production, livestock, and forestry products to develop climate-smart technologies with farmers, catalyzing and facilitating innovation process.
2. Participatory methods and approaches enable rural innovation and innovation platforms to formulate and disseminate technologies and encourage innovation through multiple stakeholder's involvement to ensure climate-smart agriculture.
3. There is a strong case for climate-smart agriculture researchers to tap local indigenous knowledge in order to have a clear understanding of the farmer's needs and problems so that the extension personnel can go on hand in hand with the farmers.
4. Successful CSA implementation involves effective and efficient, extension providers and systems, which will require major organization and institutional reforms in most countries as well as capacity building at organization and individual levels.
5. Critical investment in relation to both on-farm capital and wider agricultural outreach programs for the implementation of CSA. All the agricultural extension service providers need to give importance to implement CSA technologies and also provide funds to develop those technologies.
6. Strengthening the capacities of policy makers, extension agents, agricultural entrepreneurs, and farmers through different climate-smart agriculture training modules for building up the organizational and institutional capacities.
7. Public private partnerships can be encouraged to promote climate-smart agriculture.

8. Development of information reservoir related to climate-smart agricultural practices, technologies, etc. that is essential success stories, case studies, and initiatives of different stakeholders across the nation.
9. A nodal agency has been established on CSA at national level to monitor and play an important advocacy role at the local level in decentralized governance structures to ensure climate-smart agriculture remains high on the policy agenda and funds are allocated for CSA programs (Saravanan et al. 2018).

13.12 Enhancement of RAS Capabilities for CSA

There is a need for broad knowledge hub to achieve the objectives of CSA, as there are changing trends in farmer's needs. But the capabilities of the RAS vary widely with this respect as there is a limited knowledge on how to capture the synergies and manage the trade-offs and the absence of landscape approach to achieve the multiple objectives of climate-smart agriculture have constrained the RAS.

RASs have little involvement in climate change adaptation and mitigation efforts in developing countries, and the RAS providers have initiated specific programs in this area. The traditional RAS activities include promotion of technology and the dissemination of information. "RAS providers face challenges in 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 constant need to adjust to changing climatic conditions" (Simpson and Burpee 2014; Rupan et al. 2018).

13.13 Shift in the Agricultural Extension Policy for the Agricultural Production System to Be Climate Smart

Capabilities for promoting climate-smart agriculture at organizational level based on GFRAS framework are as follows:

Developing capacities at organizational level for enhancing the capacities of RAS to promote climate-smart technologies and practices. Adaptation to climate change in agriculture requires a better coordination among a wide range of stakeholders at various levels, and RAS needs to establish a culture of networking and partnership development for a coordinated action. Adaptation does not occur in an institutional vacuum (Agarwal 2011). Circumstances at many different levels, within households, throughout the wider communities and within governments, affect the choices made by individual farmers (Ojha et al. 2014).

CSA is highly knowledge intensive, innovative, and multidimensional, so there is a need to improve the capacities to anticipate changes, promote planned adaptation interventions, and learn continuously from those interventions in the extension systems working as the service providers to the farmers and going beyond the individual capacity. An enabling environmental conditions (regulatory and policy

frameworks, institutional linkages, and commitment) may facilitate and support organizations to play their roles effectively. It provides the laws, regulations, and incentives that shape an organizations mandate; the roles it plays; and the way it operates.

At the national level, the need to address climate change must be recognized by and addressed through policy instruments, national policies, and programs such as National Adaptation Plans, and financial mechanisms that provide access to climate funds to implement adaptation and mitigation policies. Strengthening these policies require linking scientific assessment for effective decision making and conducting participatory governance assessments to promote more responsible governance.

Strengthening local institutions at the landscape level is the key entry point to foster co-ordination and collaboration for an integrated CSA action. Some of the specific characteristics of the enabling environment that facilitates promotion of the climate-smart agriculture are as follows:

- Political commitment to all-round development of agriculture and allied sectors
- Promotion of macroeconomic policies that provide incentives to facilitate CSA
- The capacity of policy-making bodies to adapt policies based on lessons learned from climate-smart agriculture interventions
- The capacity and willingness of all the stakeholders to engage in collaborative action
- Mechanisms that facilitate collaboration and joint action among the range of stakeholders
- Mechanisms that ensure farmers have equitable access to a variety of inputs and financial support

The following measures are critical in this context:

1. Co-ordination of RAS with a variety of stakeholders at international, national, and regional levels to plan and enable climate-smart interventions, platforms for a regular and effective multistakeholder interactions. These effective co-ordinations need to be constituted and then strengthened.
2. Strengthening the research on CSA as RAS needs more relevant technological and institutional practices adapted to a new and variable climate changes and also provide policy-relevant advices to the decision-makers on investments, policy options, and program performance. Learning and exchange of research results and good practices to benefit research on CSA.
3. The extension needs to deepen and broaden their knowledge, communication, facilitation, co-learning, and dealing with diverse groups to promote CSA.
4. Development of new training modules on CSA to the extension agencies at different levels and strengthen training to the trainers of CSA. Support by number of actors including the donors, governments, NGOs, and research bodies to strengthen and improve the extension systems.
5. Lastly, a higher level of institutional commitment to promote CSA and strengthen pluralistic RAS will be needed. At the country level, a national platform or forum

of RAS providers will be needed to play major role in strengthening the existing extension systems to raise their voice in the design and implementation of national climate and adaptation and mitigation plans (Sulaiman 2017).

13.14 Conclusion

Agriculture is the most vulnerable sector affected by climate change. It is high time for agriculture to be "climate smart" for sustainably achieving the productivity and incomes and reducing the greenhouse emissions, wherever possible and to be resilient to climate change. Climate-smart agriculture (CSA) is an integrated approach that can address several challenges interlinked with climate change. This concept now has a wide ownership among the national and international agencies, government, and civil societies with a strong focus. Although CSA has been gaining importance, its dissemination and uptake of climate-smart technologies, tools, and practices are still largely an ongoing and challenging process. In this regard, the wide dissemination of CSA practices is possible through the proactive extension. In fact, extension and advisory services can bridge the knowledge gap by providing clarity on CSA components. Through this chapter, we have discussed the role and essentiality of the rural advisory services and extension systems in the domain of climate-smart agriculture.

References

Agarwal (2011) Market-oriented agricultural advisory services (MOASS). Guidelines for setting up MOAAS pilots Study on Market-Oriented Agriculture Advisory Services (MOAAS) approaches

Boa E, Danielsen S, Haesen S (2015) Better together: identifying the benefit of a closer integration between plant health, agriculture and one health, Chapter 22. In: One health: the theory and practice of integrated health approaches. CABI, Wallingford, pp 258–259

Braun AR, Thiele G, Fernández M (2000) Farmer field schools and local agricultural research committees: complementary platforms for integrated decision-making in sustainable agriculture. ODI, London

Chakraborty M, Chakravarty D (2017) Awareness about climate change adaptation through mobile applications. MOJ Ecol Environ Sci 2(7):00050. https://doi.org/10.15406/mojes.2017.02.00050

Christoplos I (2010) Mobilizing the potential of rural and agricultural extension. FAO, Rome

Davis KE (2006) Farmer field schools: a boon or bust for extension in Africa? J Int Agric Educ Ext 13:91–97

Davis K, Babu S, Blom S (2014) Building the resilience of small holders through extension and advisory services. In: Shenggen F, Lorch RP, Yosef F (eds) Resilience for food and nutrition security. IFPRI, Washington, DC, pp 127–136

Deepika B, Suchiradipta B, Saravanan R (2018) Climate smart agriculture towards triple win: adaption, mitigation and food security. MANAGE discussion paper 5, MANAGE—Centre for Agricultural Extension Innovations, Reforms and Agripreneurship (CAEIRA), National Institute of Agricultural Extension Management (MANAGE), Hyderabad

FAO (2002) From farmer field school to community IPM—ten years of IPM training in Asia. Bangkok, Thailand. Food and Agriculture Organization of the United States (FAO), Rome, Italy

FAO (2013) Climate smart agriculture: sourcebook. Food and Agriculture Organization of the United Nations, Rome
FAO (2016a) Faoorg. http://www.fao.org/climate-smart-agriculture/overview/en/
FAO (2016b) The state of food and agriculture. Climate change, agriculture and food security. SOFA, Rome
Franzel S, Degrade A, Kiptot E, Kirui J, Kugonza J, Preissing J, Simpson B (2015) Farmer to farmer extension. Note 7. GFRAS. Good practice notes for extension and advisory services. Global Forum for Rural Advisory Services, Lindaeu, pp 1–3
Gbetibouo GA (2008) Understanding farmers' perceptions and adaptations to climate change and variability: the case of the Limpopo Basin, South Africa, IFPRI discussion paper. International Food Policy Research Institute, Washington, DC
GFRAS (2014) The "New Extensionist": roles, strategies, and capacities to strengthen extension and advisory services. Global Forum for Rural Advisory Services, pp 1–3. Retrieved from http://www.gfras.org/en/157-thenewextensionist.html
Heltberg R, Bonch-Osmolovskiy M (2011) Mapping vulnerability to climate change. World Bank policy research working paper no. 5554. World Bank, Washington, DC
Leeuwis C (2004) Fields of conflict and castles in the air. Some thoughts and observations on the role of communication in public sphere innovation processes. J Agric Educ Ext 10(2):63–76
Lipper L, Thornton P, Campbell BM, Torquebiau EF (2014) Climate-smart agriculture for food security. Nat Clim Chang 4:1068–1072
Mahato A (2014) Climate change and its impact on agriculture. Int J Sci Res 4(4):3
Meinzen-Dick R, Bernier Q, Haglund E, Markelova H, Moore K (2012) Identifying the institutions for climate-smart agriculture. In: International research workshop on Institutions for Climate-Smart Agriculture, Nairobi, Kenya, pp 10–13
Mloza Banda BC (2014) E-adaptation to climate change in Malawi, ICT Update 78
Mutoko MC, Rioux J, Kirui J (2015) Barriers, incentives and benefits in the adoption of climate-smart agriculture: lessons from the MICCA Pilot Project in Kenya. Food and Agriculture Organization of the United Nations (FAO), Rome
Nelson G, Rosegrant M, Palazzo A, Gray I, Ingersoll C, Robertson R, Tokgoz S, Zhu T, Sulser T, Ringler C, Msangi S, You L (2010) Food security, farming and climate change to 2050. International Food Policy Research Institute, Washington, DC
Ngara T (2017) Climate smart agriculture manual for Zimbabwe. Climate Technology Centre and Network, Denmark
Ojha HR, Sulaiman VR, Sultana P, Dahal K, Thapa D, Mittal N, Thompson P, Bhatta G, Dutt GL, Aggarwal P (2014) Is South Asian agriculture adapting to climate change? Evidence from Indo-Gangetic Plains
Padgam J (2009). Agricultural development under a changing climate: opportunities and challenges for adaptation, joint departmental discussion paper—issue 1, Agricultural and Rural Development & Environment Departments. The World Bank, Washington, DC
Palaniswami K, Kumar DS, Malik RPS, Raman S, Kar G, Monhan K (2015) Managing water management research: analysis of four decades of research and outreach progress in India. Econ Polit Rev 26–27:33–43
Porter J, Xie L, Cochrane K, Howden SM, Iqbal MM, Lobell DB, Travasso MI (2014) Food security and food production systems. In: Field CB et al (eds) Climate change 2014: impacts, adaptation and vulnerability. Part A: global and sectoral aspects. Contributions of the working group II to the fifth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, pp 485–533
Pralle S (2009) Agenda setting and Climate Change. Environ Polit 18(5):781–799
Rupan R, Saravanan R, Suchiradipta B (2018) Climate smart agriculture and advisory services: approaches and implementations for future. MANAGE discussion paper 1, MANAGE- Centre for Agricultural Extension Innovations, Reforms and Agripreneurship (CAEIRA), National Institute of Agricultural Extension Management (MANAGE), Hyderabad

Sala S, Rossi F, David S (2016) Supporting agricultural extension towards climate smart agriculture: an overview of existing tools. Global Alliance for Climate Smart Agriculture (GASCA)/FAO, Rome, pp 28–30

Saravanan R, Karthikeyan S, Vincent A (2018) Extension and advisory services for climate smart agriculture. Extension NEXT, MANAGE Bulletin 3. National Institute of Agricultural Extension Management (MANAGE), Hyderabad

Settle W, Soumare M, Sarr M, Garba H, Poisot AS (2014) Reducing pesticide risks to farming communities: cotton farmers field school in Mali. Philos Trans Rural Soc 369(1639):20120277

Shafiq F, Ahsan K, Adnan Nadeem MS, Shaikh AB, Siddiq M (2014) Role of ICT in climate change monitoring: a review study on ICT based climate change monitoring services. Res J Recent Sci 3:123–130. ISSN: 2277-2502

Simpson B, Burpee G (2014) Adaptation under the new normal of climate change: the future of agricultural extension and advisory service. MEAS Brief no. 3. University of Illinois-Champaign, Champaign, IL

Speranza IC (2010) Resilient adaptation to climate change in African agriculture. German Development Institute, Bonn, pp 157–227

Stigter CJ, Winarto YT (2013) Science Fields Shops in Indonesia. A start of improved agricultural extension that fits a rural response to climate change. J Agri-Food Appl Sci 2(2):112–123

Sulaiman RV (2017) Enabling advisory services for climate-smart agriculture. Key elements to foster farmers' adaption of CSA practices. Policy Brief. FAO, Rome

Sulaiman R, Devis K (2012) The "New Extensionist": roles, strategies, and capacities to strengthen extension and advisory services. Global Forum for Rural Advisory Services, Lindau

Sulaiman R, Chuluunbaatar D, Vishnu S (2018) Upscaling climate smart agriculture—lessons for extension and advisory services. Occasional papers on innovation in family farming. FAO, Rome

Venkatramanan V, Shah S (2019) Climate smart agriculture technologies for environmental management: the intersection of sustainability, resilience, wellbeing and development. In: Shah S et al (eds) Sustainable green technologies for environmental management. Springer Nature Singapore Pte Ltd., Singapore, pp 29–51. https://doi.org/10.1007/978-981-13-2772-8_2

Venkatramanan V, Shah S (2020) Synergies between gender mainstreaming and food security. In: Leal Filho W et al (eds) Gender equality, encyclopedia of the UN sustainable development goals. Springer Nature, Cham. https://doi.org/10.1007/978-3-319-70060-1_18-1

Waddington H, White H (2014) Farmer field schools: from agricultural extension to adult education. Systematic review summary 1. International Initiative for Impact Evaluation, London, 15 pp

Winarto YT, Stitger K, Anantasari E, Hidayah SN (2008) Climate field schools in Indonesia: improving "response farming" to climate change. Leisa Magazine, 24

World Bank (2018) South Asia's hotspots: impacts of temperature and precipitation changes on living standards. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/28723

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