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CLIMATE SMART AGRICULTURE PRACTICES IN INDIA

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Abstract

Climate smart agriculture (CSA) can be defined as sustainably increasing agricultural productivity and incomes, adapting and building resilience to climate change and reducing green gas emissions. CSA is an approach to increase the technical, policy and investment on environment to get sustainable agriculture growth for food protection under climate change **(Climate smart agriculture sourcebook, 2013)**. Climate smart agriculture is an approach to help to guide actions to transform and reorient agricultural systems to effectively and sustainably support development and food security under a changing climate **(FAO, 2010).** "Agriculture" is taken to cover crop and livestock production, and fisheries and forest management. CSA is not a new production system-it is a means of identifying which production systems are the best suited to respond to the challenges of climate change for specific locations, to maintain and enhance the capacity of agriculture to support food security in a sustainable way. FAO estimated that if the present production and consumption rates continues agricultural production should increase 60% by 2050 to meet the needs of food of world's population. More fruitful and more flexible agriculture requires a most important change in the way of use of land, water, soil nutrients and genetic resources management by climate Smart Agriculture Techniques **(Amin et al, 2015).**

Key words: climate smart agriculture, sustainability, food protection.

Introduction

Climate-smart agriculture is an approach to help guide actions to transform and reorient agricultural systems to effectively and sustainably support development and food security under a changing climate. "Agriculture" is taken to cover crop and livestock production, and fisheries and forest management. CSA is not a new production system – it is a means of identifying which production systems and enabling institutions are best suited to respond to the challenges of climate change for specific locations, to maintain and enhance the capacity of agriculture to support food security in a sustainable way. The overall aim of CSA is to support efforts from the local to global levels for sustainably using agricultural systems to achieve food and nutrition security for all people at all times, integrating necessary adaptation and capturing potential mitigation. Three objectives are defined for achieving this aim:

(1) Sustainably increasing agricultural productivity to support equitable increases in incomes, food security and development;

(2) Adapting and building resilience to climate change from the farm to national levels; and

(3) Developing opportunities to reduce GHG emissions from agriculture compared with past trends.

Objectives / Pillars of CSA

National food security and development goals, to tackle three main objectives.

1. Sustainably increasing agricultural productivity and incomes

Around 75% of the world's poor live in rural areas and agriculture is their most important income source. Experience has shown that growth in the agricultural sector is highly effective in reducing poverty and increasing food security in countries with a high percentage of the population dependent on agriculture (World Bank, World Development Report. 2008). Increasing productivity as well as reducing costs through increased resource-use efficiency are important means of attaining agricultural growth. "Yield gaps" indicating the difference between the yields farmers obtain on farms and the technically feasible maximum yield, are quite substantial for smallholder farmers in developing countries (FAO, The State of Food and Agriculture. 2014). Similarly, livestock productivity is often much lower than it could be. Reducing these gaps by enhancing the productivity of agro-ecosystems and increasing the efficiency of soil, water, fertilizer, livestock feed and other agricultural inputs offers higher returns to agricultural producers, reducing poverty and increasing food availability and access. These same measures can often result in lower greenhouse gas emissions compared with past trends.

2. Building resilience to climate change

According to the recently released fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC), the effects of climate change on crop and food production are already evident in several regions of the world, with negative effects more common than positive ones, and developing countries highly vulnerable to further negative impacts from climate change on agriculture (IPCC Summary for Policymakers. IPCC Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects, eds Field, C. B. et al. Cambridge Univ. Press, 2014). In the medium and long term, average and seasonal maximum temperatures are projected to continue rising, leading to higher average rainfall, but these effects are not evenly distributed. With globally wet regions and seasons getting wetter and dry regions and seasons getting drier (Porter, J. R. et al. in Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects, eds Field, C. B. et al. 485–533. IPCC, Cambridge Univ. Press, 2014). There is already an increase in the frequency and intensity of extreme events, such as drought, heavy rainfall and subsequent flooding and high maximum temperatures. The increased exposure to these climate risks, already being experienced in many parts of the world, poses a significant threat to the potential for increasing food security and reducing poverty amongst low-income agricultural-dependent populations. It is possible to reduce and even avoid these negative impacts of climate change – but it requires formulating and implementing effective adaptation strategies. Given the site-specific effects of climate change, together with the wide variation in agro-ecologies and farming, livestock and fishery systems, the most effective adaption strategies will vary even within countries. A range of potential adaptation measures have already been identified which can provide a good starting point for developing effective adaptation strategies for any particular site. These include enhancing the resilience of agro-ecosystems by increasing ecosystem services through the use of agro-ecology principles and landscape approaches

3. Developing opportunities to reduce greenhouse gases emissions compared to expected trends

Agriculture, including land-use change, is a major source of greenhouse gas emissions, responsible for around a quarter of total anthropogenic GHG emissions. Agriculture contributes to emissions mainly through crop and livestock management, as well as through its role as a major driver of deforestation and peatland degradation. Non-CO_2 emissions from agriculture are projected to increase due to expected agricultural growth under business-as-usual growth strategies. There is more than one way agriculture's greenhouse gas emissions can be reduced. Reducing emission intensity (e.g. the CO_2eq/unit product) through sustainable intensification is one key strategy for agricultural mitigation (Smith, P. et al. in Climate Change 2014: Mitigation of Climate Change Ch. 11. IPCC, Cambridge Univ. Press, 2014). The process involves implementation of new practices that enhance the efficiency of input use so that the increase in agricultural output is greater than the increase in emissions (Smith, P. et al. in Climate Change 2014: Mitigation of Climate Change Ch. 11. IPCC, Cambridge Univ. Press, 2014). Another important emissions reduction pathway is through increasing the carbon-sequestration capacity of agriculture. Plants and soils have the capacity to remove CO_2 from the atmosphere and store it in their biomass – this is the process of carbon sequestration. Increasing tree cover in crop and livestock systems (e.g. through agro-forestry) and reducing soil disturbance (e.g. through reduced tillage) are two means of sequestering carbon in agricultural systems. However, this form of emissions reduction may not be permanent – if the trees are cut or the soil ploughed, the stored CO_2 is released.

Strategies for climate smart agriculture

Climate smart agriculture can be adapted through a number of techniques. For instance:

Methane (CH_4) emissions as a result of rice farming can be altered by water management efficiently, getting better management of organic wastes by promoting aerobic decomposition via the process of composting or incorporate soil for the period of the off-term drainage; use of rice varieties with a few infertile tillers, high oxidative roots and higher harvest index; and use of fermented fertilizer as biogas slurry compost instead of unfermented one (Pathak and Wassmann, 2007). Land use management practices such as reduced tillage, manure and wastes enhance the integration of soil biodiversity, assembly and partial coverage can play a vital role in the accumulation of carbon in the soil (Pathak and Wassmann, 2007). So, the effects of climate change can be solved by climate smart agriculture such as developing new varieties which are tolerant to heat, salinity and resistant to floods and drought, improving water management, following new agricultural technologies such as resource conservation and effective management techniques, crop diversification, improved pest management, crop modelling and better weather forecasting. These strategies are discussed below.

Efficient Resource Management

Resource management is very significant feature of CSA and future climate. Food loses are found through all stages of the food production till food utilization. Almost one third part of food produced is wasted (Gustavsson et al., 2011). The energy consumed in annually world food losses are almost 38 % of the final energy utilized by the total food chain. All the food chains, from agricultural, transport, conservation, processing, cooking and consumption are likely areas for improving energy use efficiency (FAO, 2011). In the continent of Africa, 90% of the removed wood is used for manufacturing household articles and also, for cooking. Better energy saving in cooking stoves can help to decrease deforestation

Integrated renewable energy technologies for farming systems

The suitable energy technologies, tools and different services in farming fields are important to create the stable change to energy smart and proficient food systems. The nature of all these technologies will be governed by natural conditions, transportation and including the promotion of mid-season aeration through short-term drainage; skills available in the labour force. A number of new technologies that can be very important for energy smart food systems include: wind mills, solar panels ,photovoltaic lights, biogas extraction units, power generators, tools for bio-oil mining and purification, fermentation and distillation processes for ethanol extraction, pyrolysis units, hydrothermal conversion tools, solar-wind electricity production or bio energy-operated water pumps, renewable energy-powered vehicles, monitoring systems, information and communication technologies (ICT), cooking stoves, equipment for water supply, distribution and purification.

These newly developed technologies increased value to manufacture by the availability of raw resources.

Availability of technical knowledge of farmers

In South Asia farmers mostly belong to poor families and are limited to their recourses, so they are experimenting with climate variability for centuries. They have abundance of knowledge techniques with the number of steps that can be used in the development of technologies for controlling climate vulnerability. This type of knowledge is required to fulfil the modern needs. Conventional environmental knowledge of people improved and developed in the test of time could give different ideas and feasible options for adaptation procedures. Studies have concluded that the observation of traditional farmers was quite evolved in the affairs of earthquakes, landslides and drought and they have developed better techniques to alleviate the effect of natural and climatic variations.

Role of Institutions for CSA improvement

Those institutions are essential which create and transfer useful information and guide people to interpret the new technologies into understanding and work on it. The institutions such as farmer field schools that guide and facilitate farmers for the implementation of new techniques; Shows of farm radio that share agricultural information which is easily available, useful, useable and weather-related knowledge to local rural people; agricultural plots exhibitions to the community and exchange of ideas between farmers.. The profits achieved by using those management techniques which are sustainable for the land usually take time to appear. During this time, the farmers have to tolerate the total expenditure that includes expenditure of labour, land and cash (McCarthy et al., 2011). Since poor farmers have no resources to access credit and markets, and they are unable to adapt to these new techniques for the success of CSA the strong institutions have to maintain agricultural markets and financing mechanisms which are very important. The most efficient technique allows researchers, private sector investors, community members and policy makers to collectively describe troubles that are planned to resolve (Kristjanson et al., 2009).

Resource conserving technologies

The resource conserving technologies (RCTs) consists of techniques that enhance efficiency in management of resources or application of inputs and hence use of direct, identifiable and comprehensible economic advantages like decline in production costs; saving fuel, labour and water; and the timely sowing of crops, resulting in improved yields. The RCT such as zero tillage systems (ZT) or no-tillage is a cultivation system in which seeds are directly sowed into uncultivated soil. It can be explained "as the system of cultivating crops into untilled soil by creating thin channels that only have adequate depth and width to attain suitable seed coverage. Remaining soil is left as if no tillage is done with it (Derpsch et al., 2010).ZT permits the farmers to plant wheat soon after the rice harvest or cotton, so that the heads of crops appear and the grains fill before the arrival of warm weather pre-monsoon. As average temperatures in the certain region rise, early planting will be gradually more important for wheat (Pathak et al. 2009).

In the rotation of rice and wheat no tillage is practiced on 5 million hectares in the India, Pakistan, Bangladesh and Nepal (Hobbs et al., 2008). If the disturbance of soil is less, the retention of organic matter can be more in the shape of stored carbon, that's why it does not take part in global warming in the form of CO2 production. Therefore no-till has much share to greenhouse gas alleviation by improved carbon sequestration in the soil (Zingore, et al. 2010). In developing countries only a few long term studies about soil having organic carbon changes under different tillage regimes have been conducted. The conversion of conventional tillage to no-till is often considered to be an efficient and successful carbon sequestration strategy having a sequestration rate of 367-3667 kg CO2 ha-1 year-1 (Tebrügge, et al., 2011).

Crops Genetic Modification

Environmental stress mostly affects the decay of organic matter in the soil, availability of nutrients and water to the plant and recycling of water and nutrients. Nutrient concentration and period of environmental limits conclude level of effect on crop growth cycle and biomass accumulation. Crop yields in Asia are estimated to decrease by 2.5-10% from 2020 onwards and by 5-30% after 2050, with most horrible decrease in South and Central Asia (Cruz et al., 2007). Adjustment techniques can be enhanced by the availability of new crop varieties that are tolerant to heat, drought and salinity and thus reduce the risks of climate situation. Genetic diversity of the seed structure and seed composition has been recognized as a very effective defence against plant disease and pest attack and risks of climate. Similarly, for the compensation of the emerging problems of crop cycle decreases and the other vagaries of the production environment, it is required to develop the varieties. Due to the genetic modification the global yield of vegetables has doubled in the last 25 years and due to this, worldwide trade in vegetables is much higher in volume than that of cereals. Total world's vegetable land is 53.98 million hectares which give total production of 1012.52 million tons (NHB, 2011).

Land-use Management

Changing land use practices, like the location of crops and livestock production, rotation or shifting production between livestock and crops, shifting production out of marginal areas, changing the intensity of the application of fertilizers and pesticides, capital and labour can help minimize the risks from climate change on production of agriculture. Adjustment of sequence of the crop by altering the time of sowing, spraying, and harvesting the crop, in order to take benefits of the altering length of seasons of growth and levels of changing heat and humidity associated is one more option. Changing the time at which the fields are sown can also help the farmers to regulate the length of the growing season for the better adaptation to the altering environment. Adaptations of farmers can also be involved by changing the timing of irrigation or the use of other elements like fertilizers.

Cropping Season variation

Planting dates can be set to reduce the infertility induced by the increased temperature which may save the flowering period to coincide with the hottest period. Mitigation strategies to reduce the negative effects of increased climate variations as normally experienced in semi-arid tropics and arid regions may consist of changing the sowing or planting dates to take benefit of the wet period and to avoid intense weather events in the growing season. Changed cultivation systems include improving the better cultivars and enhancing the intensity of farming various crops. Farmers will have to manage the changes in different hydrological regimes by adopting changed crop rotations (Pathak et al., 2012).

Crops Relocation

Climate change causes the increase in temperature and CO2 levels, raises the chances of droughts and floods; all these factors affect crop yields. But the effects will vary between cultures and regions. It is necessary to differentiate regions and crops that are very much prone to climate change / variability so these should be repositioned to more appropriate areas. For example, this is known that as temperature rises it affects the quality of many important crops such as aromatic Basmati rice and tea. Different other areas that would be more appropriate for these kinds of crops with respect to quality must be identified and evaluated for suitability.

Efficient pest management

Variations of temperature and rainfall unpredictably influence pest and disease incidence and extremeness on major crops. It is due to the effect of climate change that will inherently affect the relationship of pest / weed, the host population and pest / weed hosts interactions

Integration of modelling and forecasting

Although there remain some uncertainties owing to lack of knowledge, crop simulation models can appreciably estimate and quantify the impact of specific water stress conditions (possible due to climate change) on crop productivity if these are well calibrated and validated in field experiments (Wolf et al., 1996; Grossman-Clarke et al., 2001;). The crop models permit variation of environmental factors such as the water regime and temperature and simulate the crop response via many calculated growth parameters like crop yield. Due to the complexity of the problem, research continues and improvements are constantly being made to models, for example, drought impact assessments. Jamieson et al. (1998) compared the models AFRCWHEAT2, CERES (Crop Environment Resource Synthesis) Wheat, Sirius, SUCROS2 and SWHEAT with measurements from wheat grown under drought. CERES-Wheat has proved to be useful for forecasting drought effects on crops at specific locations (the uncertainty of yield prediction was found to be below 10%). CERES-Wheat is well referenced and has been successfully tested in a number of studies (Ritchie et al., 1998), especially for climate change effects on growth (Tubiello et al., 1999; Zalud et al., 1999).

GIS mapping

GIS (Geographical Information System) is used in analysis and mapping which helped in the estimation and computation of the storm course and flooding associated with hot cyclones. The study incorporated population allocation, infrastructure and other under threat resources. These photographs and images were also used in the investigation of seashore due to hot cyclones and rising sea levels. Figure 3 shows Risk which can be explained by the cumulative study of possible threats and existing situations of vulnerability. Risk and hazard maps can be created at different possible scales to show the threat allocation across different geographical regions. These regions can be site specific, include provincial or municipal administrative areas and other small national landscapes, like river basins, coastlines and lakes.

Different elements of climate-smart agriculture

1. Management of farms, crops, livestock, aquaculture and capture fisheries:

What is most “climate-smart” depends strongly on biophysical and socio-economic contexts. Options for crops include switching varieties or species, changing cropping calendars, and nutrient management such as micro-dosing, mulching or organic fertilizers application.

Options for livestock include improving the quality of pastures and feed, changing herd management, and specific responses to heat stress.

In fisheries, changes in locations, quotas and species are all relevant, while in aquaculture, combining species and managing temperature are climate-smart options.

Overall farm-management options include diversification of production, integrated crop-livestock systems, agroforestry, restoring organic soils, limiting soil erosion, energy efficiency, use of biomass fuels, integrated pest management, and enhancing management of water resources and irrigation.

2. Landscape or ecosystem management:

CSA also encourages looking at agricultural systems in the context of larger landscapes and ecosystems, so as to better understand the inter-linkages between agricultural production and ecosystem services within and external to agro-ecosystems. The role of water-resource management and land-use change in food security, adaptation and mitigation across landscapes is an important element. Regulating ecosystem services such as hydrology or biodiversity, including in the soil, can generate production, adaptation and mitigation co-benefits. Multiple objective forest management can generate benefits for food security, development, adaptation to climate change (microclimate), water management, soil protection, agro-biodiversity protection (pollinators) and assist with carbon storage and greenhouse gas emission reduction.

3. Services for farmers and land managers:

Increasing adaptive capacity of farmers, herders, fishers and foresters requires increasing a range of services. These include climate information services, such as seasonal forecasts or early-warning systems, advisory services that link climate information to agricultural decisions, and financial services such as credit and insurance. Social protection as well as new index-based weather insurance products can increase the ability of smallholders to invest in agriculture despite increasing climate variability.

4. Changes in the wider food system:

Agricultural production is not the only focus of adaptation and mitigation actions that support food security and livelihoods. Across the value chain, innovations in harvesting, storage, transport, primary and secondary processing, retail and consumer activities are essential elements of the enabling and incentivizing environment needed for CSA.

5. Improved soil fertility and crop management practices:

Composting, Cover cropping, Conservation agriculture, Efficient use of fertilizer Improved, high yielding varieties use, Use of stress tolerant varieties and Alternate wetting and drying for rice management**.**

Adaptation and risk management intervention in the CSA

Water smart

Resilient water management practices which aim at enhancing the efficiency and productivity of water, are critical climate smart interventions. These could include aquifer recharge, rainwater harvesting, community management of water, laser land levelling, water conservation, drip irrigation and on farm water management practices. For instance, drainage is important in places that are prone to becoming waterlogged, such as Bihar in India and Bangladesh. Vertical drainage systems are being evaluated in Bihar with the expectation that it will help floodwater seep more quickly back into the natural aquifer, providing the dual benefit of recharge and protecting standing crops.

E.g: Aquifer recharge, Rainwater harvesting , Community management of water and Laser-levelling, On-farm water management.

Weather smart

For farmers, information of near-term weather events go a long way in planning climate resilient agricultural production. Farmers are linked to weather information and value-added agro-advisories through radio shows, television, newspapers and mobile phone voice messages. Farmers can use index based insurance schemes to cover risks associated with changes in rainfall and temperature at the different stages of crop growth.

E.g: Weather forecasts, ICT-based agro advisories, Index-based insurance and Climate analogues.

Nitrogen smart

In Climate-Smart Villages, farmers use leaf-colour charts, handheld crop sensors, and nutrient decision-maker tools to decide the most appropriate dosage of nitrogen fertilizers for their crops. This saves on costs and also cuts down on greenhouse gas (GHG) emissions.

e.g. Site-specific nutrient management, Precision fertilizers and Catch-cropping/ legumes

Carbon smart

Carbon content in the soil can be increased through agricultural practices such as agroforestry, livestock and manure management, conservation tillage, diversified land-use systems and residue management. e.g. Agroforestry, Conservation tillage, Land-use systems and Livestock management

Energy smart

CCAFS promotes fuel-efficient agro machineries, residue management and reduced tillage as interventions to conserve energy and reduce GHG emissions. In some cases, biogas systems are promoted using manure slurry from intensive dairy enterprises as part of the portfolio of innovations. e.g. Biofuels, Fuel-efficient engines, Residue management and Minimum tillage

Knowledge smart

CCAFS and partner organizations arrange cross-site visits of farmers to analogue sites and to other areas practising climate smart agriculture. An innovative approach of crowdsourcing seeds is used in Climate-Smart Villages. A large number of farmers are provided with seed packets of adapted varieties to evaluate those best suited to their local conditions. They provide feedback to researchers to help them develop better varieties. e.g. Farmer-to-farmer learning, Community seed and fodder banks, Market information and Off-farm risk management

Conclusion

* Climate change alters agricultural production and food systems, and thus the approach to transforming agricultural systems to support global food security and poverty reduction.
* Improving food protection by moderate climate change, sustainably use the natural resource, use all products more competently, have less inconsistency and greater constancy in their outputs.

REFERENCES:

Ahmad MI, Ali A, Ali MA, Khan SR, Hassan, SW, Javed MM. 2014. Use of Crop Growth Models in Agriculture: **A Review. Science International, pp: 26**.

Amin A, M. Mubeen, HM. Hammad and W. Nasim . 2015 Climate smart Agriculture: an approach for sustainable food security, **Agric.Res.Commun. 2(3): 13-21.**

Climate Smart Agriculture Sourcebook executive summary. 2013. Rome, Italy. **http://www.climatesmartagriculture.org/72611/en/8.**

FAO & CCAFS. (2013) Gender and Climate Change Research in Agriculture and Food Security for Rural Development Training Guide. Rome, Italy. http://www.fao.org /docrep/018/i3385e/i3385e.pdf.

Financing Climate-smart Agriculture 375–406 (Climate-Smart Agriculture Sourcebook Module 14, FAO, 2013).

Food and Agriculture Organization, 2010 "Knowledge on climate smart agriculture"

Jerry Knox, Tim Hess, Andre Daccache and Tim Wheeler. 2012. Climate change impacts on crop productivity in Africa and South Asia**, Environ. Res. Lett. 7**.

IPCC Summary for Policymakers Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects (eds Field, C. B. *et al*.) (Cambridge Univ. Press, 2014).

McCarthy, N., Lipper, L. & Branca, G. Climate-Smart Agriculture: Smallholder Adoption and Implications for Climate Change Adaptation and Mitigation (Mitigation of Climate Change in Agriculture Series No. 4, FAO, 2011).

Pampi Paul and Mukesh Kumar. 2016. Climate smart agriculture with gender perspective, **IMPACT: Intl. J. of Res. in Applied, Natural and Social Sci.4(9) :**25-32.