Climate Smart Agriculture (CSA)

G.A.S. Ginigaddara, PhD
Rajarata University of Sri Lanka
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1. Need for Climate Smart Agriculture

1.1. Climate Changes

Climate and Agriculture terms are closely linked in crop production technologies. Each crop characters vary with their growing climatic region. Production and the final yield of crops will be determined depending on the environmental conditions governing in the specific climatic zone. Therefore, climate is much important factor in crop production, distribution and the abundance of species. For example, CO$_2$ is major input in photosynthesis and have potential important on plant and also indirect important for animal food chain. On one hand, CO$_2$ concentration is needed for ecosystem functioning and on the other hand, it's harmful for some other processes. Therefore, increasing temperatures, powerful rainstorms, high wind pressures like extreme weather conditions have much influence on the agricultural activities.

Increasing CO$_2$ gas ultimately increases the global temperature which is called as global warming. Natural global warming is not harmful for the biota and enhanced man-made global warming is one of the major threats to environment. Disturbing agriculture with higher CO$_2$ quantities, increase in atmospheric average temperature, large glacial overflow, varied rainfall sequence and the interrelation of all the above factors are experienced with enhanced global warming. Major causes for CO$_2$ emission are recognized as fossil fuel burning, deforestation and mechanization. With the industrial revolution, the CO$_2$ emission rates were drastically increased and its influence to ecological and environmental balance was very bad. Not only CO$_2$, N$_2$O, CH$_4$ and CFC are greenhouse gasses which deplete the ozone layer and that affecting on enhancing the temperature.

Agricultural practices lead to enhanced greenhouse gas emission. It has been estimated that 58% of N$_2$O emissions were normally through the application of
fertilizers onto soils. Therefore, fertilizer management according to the crop demand is much important in Agriculture. The share of CH₄ is about 40 % of total GHG emissions and it does so through its release by livestock and rice cultivation. These are released due to the organic compounds digestions in the respective cites. All these greenhouse gases contribute to the agricultural practices and natural processes. Climate is a broad term which is used to describe long term environmental processes. Changing the rainfall pattern, floods, continuous drought conditions are occurred due to the changes in regular climatic conditions.

1.2. Climate Change and Agriculture

Climate change has become major problem to the sustainability of livelihood. The rate of climate change year by year has become major issue for the world. The direct effects are harmful for increasing world population, income generating issues and finally affect the whole food security all over the globe. There will be lack of availability, access and utilization of food which they used for the nutrient supplement. Increasing temperatures enhance the weed and pest population of the field and their biological functional rates that coarse the reduction of the final yields of important crops. It has threatened to the population of the under-developed world, which is already prone to climate change and food deficit, would be affect the most.

Climate changes will increase additional cost for production and the market prices for main agricultural food crops such as rice, wheat, corn, soybeans and also vegetables. For example, huge price increase at the flood situations and with the continuous rainfall. Various impacts of climate variations on agriculture and human interests are;
• natural exceptional effects on crop yields on which dairy and other livestock production
• the overall variation in outcomes including prices, production, and consumption and
• the change in per capita calorie consumption

Sustainability is a crucial guiding principle for international environmental policy and decision making in the twenty first century. The worst issues of climate change could be controlled by successful adaptation, which would probably be less than the cost of impacts that would occur without adjustments.
2. Climate Smart Agriculture (CSA)

Climate Smart Agriculture is a concept which is not a novel concept and practiced in national and international level to meet the challenges with proper planning to address the climate changes in agriculture. It is practicing sustainably to increase agricultural productivity and income, adapting and building resilience to climate change and reducing greenhouse gases emissions. One of the methodological aspects is to increase technical, policy and investment on environment to reach sustainable agricultural growth for food protection under climate change.

Many authors define Climate Smart Agriculture (CSA) as an approach for transforming and reorienting agricultural systems to support food security under the new realities of climate change. There are many other terms related to agricultural development, but CSA is novel in its focus on a range of climate actions. According to the Food and Agriculture Organization (2010), CSA is defined as “agriculture that sustainably increases productivity, enhances adaptation and reduces GHGs emission and enhances achievement of national food security and development goals”.

With the increasing population, food security in the world has always been difficult. It will become more challenging under a changing climate. According to the Intergovernmental Panel on Climate Change (IPCC), a temperature increase of 2°C could reduce agricultural yields by 15 per cent with current farming practices, while the FAO states that 60 per cent more food is needed by 2050 to meet the growing population demand.

As well as food systems have higher negative impacts on greenhouse gas emissions, with the agronomic practices. Therefore, these manageable practices have to be regulated to mitigate the greenhouse gas emission and global warming. Climate-Smart Agriculture is an approach to address these challenges in a comprehensive manner.
3. Three pillars of Climate Smart Agriculture

Climate Smart Agriculture is an approach which was build up with the combination of three pillars to achieve their objectives (Figure 01).

![Three pillars of CSA](source: FAO, Climate-Smart Agriculture)

**Figure 01:** Three pillars of CSA (Source: FAO, Climate-Smart Agriculture)

01: Sustainably increasing agricultural productivity and incomes

CSA aims to sustainably increase agricultural productivity and income from crops, livestock and fish, without having a negative impact on the environment. This will improve the food and nutritional security. This is a key concept related to raising productivity through the sustainable cultivation practices parallel to the reduction of climate impacts and greenhouse gas emission.

02: Reducing and/or removing greenhouse gases emissions

CSA helps to reduce and/or remove greenhouse gas (GHG) emissions. This indicate how much of gas releasing to the environment thorough the process of food production. Through CSA, reduce emissions of fuel per each calorie or kilo of food,
fiber that we produce. With CSA, we avoid deforestation. We manage soils and trees in ways that maximizes their potential to acts as carbon sinks for atmospheric CO₂ (Figure 02).

Figure 02: GHG emission with respect to Agriculture
Source: http://sdwebx.worldbank.org/climateporta

03. Adapting and building resilience to climate change

CSA aims to reduce farmers’ exposure to short-term risks, like food price changing and status imbalance while also strengthening their livelihood pattern. The short-term goals are improving their capacity to adapt and face for the shocks and longer-term stresses with cultivation practices. Particular attention is given in protecting the ecosystem services which ecosystems provide to farmers and others. These services are essential in maintaining productivity in the agricultural fields and ability to adapt to climate changes.
4. CSA vs. Sustainable Agriculture

CSA is a term which describe simply as the term sustainable agriculture with a strong focus on the climate dimensions. For example,

- Focusing on climate advisories for farmers (where appropriate),
- Scaling up weather-based index insurance (where appropriate),
- Mobilizing climate finance for the benefits of farmers (where appropriate).

If sustainable agriculture completely follows up in the system, the emerging ideas in CSA, there will be no reason for the CSA concept to continue – climate concerns will be completely focus on to sustainable agriculture.

FAO considers CSA as a combined policy, technology and financing approach to enable countries to achieve sustainable agricultural development under climate change. Similar goals in CSA, other approaches are food security and sustainable development, CSA distinguishes itself in three ways.

- CSA systematically integrates climate change into the planning and development of agricultural systems. While many approaches to sustainable agriculture consider resilience and reduction of greenhouse gas emission as beneficial side effects, CSA takes them as starting points.

- To achieve the three outcomes of productivity, adaptation and mitigation, CSA emphasizes the synergies and trade-offs between interventions at different levels. This is important, because interventions can have beneficial socio-ecological effects at farm level, but detrimental effects at landscape or community level. To identify optimal interventions and assist farmers and decision-makers, CSA projects need to deploy prioritization tools to identify trade-offs and synergies between options.
• CSA attracts new funding to agricultural development, as it focuses explicitly on climate change. With the need for climate change adaptation and mitigation, a numerous of climate funds has appeared, such as the Least Developed Countries Fund, the Global Environment Facility Trust Fund and the Green Climate Fund.
5. Strategies adopted in Climate Smart Agriculture

There are several strategies which have practiced, to reach the goals in climate smart agriculture. In term of Agriculture, major gas release with the agriculture process is the Methane (CH4) as a result of rice farming can be controlled with proper water management, getting better management of organic wastes by promoting aerobic decomposition via the process of composting or incorporating 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 can reduce the greenhouse gas emission.

Land preparation methods such as reduced tillage or zero tillage, manure and wastes enhance the combination of soil biodiversity, complete or partial coverage can play a vital role in the accumulation of carbon in the soil. In compost manufacturing process the term of covering using black polythene or soil layer is much important for the reduction if carbon release to the environment and accumulate as the sink in the composting process. 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 modeling and better weather forecasting.

5.1. Use of integrated renewable energy technologies

In modern agricultural technologies are highly practiced to improve the efficiency of work and to reduce the labor usage. The type of energy usage system, tools and different services in farming fields are important to create stable change in the food system and use to create smart energy usage systems for the food production. 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 labor force. A number of new technologies can be very important for energy smart food systems including:

- Wind mills (Figure 03)
- 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
- Equipment for water supply
- Distribution and purification.

![Figure 03: Energy smart food systems (Left- bio char production and right- wind mills)](image)

In traditional food systems, bioenergy was used as the energy source. With the industrialization, fossil fuels have been used with increased farm mechanization, boosted fertilizer production and improved food processing and transportation.
Energy and agri-food systems linkage has been strengthening with chemical fertilizers, irrigation and machinery usages. Post-harvest activities, such as food storage, processing and distribution, are also energy-intensive. Over the last decades, the increased use of energy by the agricultural sector has significantly contributed to feed the world.

These newly developed technologies increased value to manufacture by the availability of raw resources. These technologies can be interconnected on a farm in terms of integrated food energy systems (Figure 04).

**Figure 04:** Integrated renewable energy technologies for farming systems (Source: IPCC, 2007)
5.2. Efficient Resource Management

Resource components like land, labour, and capital are effectively used under the climate smart agriculture for sustaining the production and food security. With the CSA, it is needed to know how the resources are utilized effectively and their management is very significant feature of CSA and future climate.

As for the production chain, food loses are being to higher at each stage until they reach to the consumer’s hand. Losses in the food chain has large impact at the final stage of the chain due to it affects for the food security and the availability of the food at any time for any person. Almost one third, part of food produced is wasted through the food chain. Every year, the energy consumed in world food losses are almost 38 % of the final energy utilized by the total food chain. The key rings of the food chain where improving energy use is higher from harvesting, transport, conservation, processing, cooking and until consumption. Mostly wasting the resource uses at the household level can be reduced by cooking ovens instead of deforestation by wood wastages.

5.3. Availability of technical knowledge of farmers

Most of poor families in South Asian countries are experiencing climate variability for centuries. They have poor techniques with abundance of knowledge with the number of steps that can be used in the development of technologies for controlling climate changes. This type of knowledge is required to fulfill the modern needs especially, world food needs. Conventional agriculture practicing farmers have the capacity to answer the questions with various pattern of ideas to improved and developed different ideas and possible options for adaptation procedures. Previous studies have showed that traditional farmers had such kind of solutions for the earthquakes, landslides, floods and drought and they have
developed better techniques to alleviate the effect of natural and climatic variations.

Cultivation pattern of the ancient farmers are most ecofriendly and that practices are more feasible to reach for the goal of climate smart agriculture. They mostly practiced zero tillage, mulching, composting, intercropping system and the multiple farming system to fulfill the day today food need and they have done less harm to the agro-eco system. These kinds of practices are reluctant to practice with the mechanization and enhanced climate change effects were happen with close time intervals. By the time of farmers realizing, again they much favor in the practice of the eco-friendly farming methods.

5.4. Role of Institutions for CSA improvement

New technologies-based farming methods and their adoptability to the present cultivation practices and the profitability also impact the agricultural productivity and incomes, adapting and building resilience to climate change and reducing greenhouse gases emissions. Those look into the new innovation of the farm product to the society. There are institutions which assign to test and popularize among the farmers, create and transfer useful information and guide people to interpret the new technologies into understanding the principles and follow up the theories on it. Most of the research stations excavate the principles and the extension officers are ready to transmit those knowledges to the field level. In that way technology has to be transfer within the chain.

The institutions such as farmer field schools, farmer organizations that guide and assist farmers for carrying out innovative techniques, telecast farm radio channels, magazines that share agricultural information which are easily available, useful and weather-related knowledge to local rural people, agricultural field exhibitions to the community and exchange ideas between farmers. Whether forecast unit
establishments in the farm level fields have much advantage to gain the knowledge and the authoritative person have assign to advice the agronomic practices and the climate combining cultivation practices (Figure 05).

Figure 05: Climate-Smart Farming
Source: www.startupcompete.com

The profits gained through the management techniques are sustainable for the land usually it will take long time duration. Until the sustainable level reached farmers have to bear the total expenditure that includes expenditure of labor, land and cash. Within that period there would not be any income or cash gain from the cultivation. 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 in the institutional supporters collaborate with the researchers, private sector investors,
community members and policy makers to support the farmers difficulties and make solutions through their expertise knowledge and practices.

5.5. **Resource conserving technologies**

The resource conserving technologies (RCTs) consists the theory behind which the resources utilized for the production practices are preserved itself. That enhances efficiency in management of resources or application of inputs. Therefore, decline in production costs, saving fuel, labor and water, and the timely sowing of crops, result in improved yields.

The best example for RCT as zero tillage systems (ZT) or no-tillage is a cultivation system

- Seeds are directly sowed into uncultivated soil.
- The system of cultivating crops into untilled soil
- Have adequate depth and width to attain suitable seed coverage.
- Remaining soil is left as if no tillage is done with it.
- The soil disturbance is less
- Retention of organic matter can be more in the shape of stored carbon
- It does not take part in global warming in the form of CO\textsubscript{2} production.
- Therefore no-till has much share to greenhouse gas alleviation by improved carbon sequestration in the soil.

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 CO\textsubscript{2} ha\textsuperscript{-1} year\textsuperscript{-1}
Example,
Plant wheat soon after the rice harvest, 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. In the rotation of rice and wheat no tillage is practiced on 5 million hectares in the India, Pakistan, Bangladesh and Nepal.

### 5.6. Crops Genetic Modification

Climate change and environmental stress mostly not only for the animals, it affects for the plant and their physiochemical reactions. Climatic modifications affect the degradation of organic matter in the soil, availability of nutrients and water to the plant and recycling of water and nutrients. With the organic matter concentration, plant nutrient concentration and period of environmental confined, determine the level of effect on crop growth cycle and biomass accumulation.

In south Asian countries, it is estimated that the crop production become declined about 2.5-10% from 2020 and 5-30% after 2050, that value indicate there may be severe food insecurity period created by the human due to the changes in climate, ultimately change with the cropping pattern. This gap of yield reduction fulfilled with introducing newly improved crop varieties to some extent. The newly introducing crop varieties are tolerant to heat, drought and salinity and thus reducing the risks of climate situation.

The new improved crop varieties are released not only as determining their yield, they are much concern on the genetic diversity of whole plant genetic pool including seed structure and seed composition has been recognized as a very effective defense against plant disease and pest attack and risks of climate. Similarly, for the benefit of the emerging problems of crop cycle decreases and the other impulses of the production environment, it is required to develop the
varieties. Researchers found that, due to the introducing new genetic modified crop varieties enhance the global crop yield by 50 per cent.

For example, vegetables has doubled in the last 25 years and due to this, According to the global trend vegetable production is much greater concern than the other cereal production in most of the countries. Total world’s vegetable land is 53.98 million hectares which give total production of 1012.52 million tons.

5.7. Land-use Management
Continuous cultivation of the similar land area with the similar agronomic practices harm to the soil health and the soil biota. Then changing land use practices, can help to minimize the risks from climate change on production of agriculture.

- Change 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
- Various forms of capital and labor

Not only land use practices, crop management practices also altering the possible techniques for facing the climate mitigations.

- Change the cropping pattern by altering the time of sowing, spraying, and harvesting the crop.
- Altering the 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.
- Changing the timing of irrigation
- Changing the use of other elements like fertilizers.
5.8. Cropping Season variation

By the meteorological data of passing 10 – 20 years, the scientist approached to predict that the climate of the next season flows in this manner. Average temperature may be in this level, average annual rain fall is about this much and light intensity is reach this much of for plants etc. Delivering the information to the farmers they change the cultivation pattern according to the seasonal variation. Planting at the correct dates can reduce the infertility of pollen grains when it received the increased temperature which may save the flowering period to correspond with the hottest period. New breeding cultivars which gives higher yield within short duration. Then it reduces the field growing period and reduce the practice of climate change intensity. Those cultivars which most are photo insensitive, that mean even it received less or higher solar energy that crop can photosynthesis better and flowering occur at the correct stage of the growing period.

- Changed cultivation systems include improving the better cultivars.
- Enhancing the intensity of farming various crops.
- Manage the changes in different hydrological regimes by adopting changed crop rotations.

Modification 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.

5.9. Crops Re-location

Climate change vary with location to location, country to country. Therefore, the strategy which are taken to solve the problem have change with the location. Climate change causes the increase in temperature and CO₂ levels, raises the chances of droughts and floods; all these factors affect crop yields. In case of temperature increase, it may much helpful for the temperate countries which are much cold countries. Then increasing temperature help to grow crops without the
controlled environmental conditions. There less need to usage of heaters for their crop cultivations.

But the effects will vary between cultures and regions. That increasing temperature may much harmful for the tropical countries which are always received worm conditions. Much increasing the temperature plays harmful effect on the crop growth, flowering and the final yield reduction. Therefore, it is necessary to differentiate regions and crops that are very much prone to climate change.

According to the changes of the climate and their location, crops should have to be re-introduce to the new locations. These known as repositioned of crops 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. Due to the changes in aromatic compounds and the flavor taste change with the fluctuating climatic regimes. Different other areas that would be more appropriate for these kinds of crops with respect to quality must be identified and evaluated for suitability.

5.10 Efficient pest management
Changes of the climate more prone to the increase the pest population in the region. With the increase temperature increase the rate of biological process, parallel to increase the pest population and their tread. As well as increase the intensity of rainfall or continuous rainfall, increase the fungus activity and their population. Therefore, unpredictable variations of temperature and rainfall influence pest and disease incidence and extreme weather conditions mostly effects on major susceptible crops. Leafy vegetables, fruit crops are prone to affect by the fungus and the pest attacks. Climate changes that will inherently affect the relationship of pest / weed, the host population and pest / weed hosts interactions.
Weed population increase in the field have direct influence to reduce the final yield. Some possible adaptation techniques can be practice to follow up for the crop management from the pest include:

- Development of cultivars resistant to diseases and pests;
- Integrated pest management (IPM) adoption having more dependence on the biological control and change in cultural practices.
- Adoption of substitute crop production and techniques, as well as places that are resistant to pests and other hazards.

## 5.11 Forecasting

Crop weather forecast and early warning systems will very helpful to minimize the threats of climate losses. If the weather alert announced by the meteorological station as there may be rain within this period, farmer can take decision to make sure their crop scheduling according to the weather forecast. For example, if the crop needs to harvest, farmers can allow it for few days delay or early harvesting. Similarly, fertilizer and pesticide application can delay due to the heavy rainfall. Administrators and researchers are much consider on the Application Information and Communications Technology (ICT) efficiently in planning the occurrence programs. There are techniques to analysis the current weather data according to the cultivation.

**Multi criteria Analysis (MCA)**

- In the field of forecasting a new technique Multi Criteria Analysis (MCA) tool has implemented to evaluate climate change policy alert on mitigation and adaptation options.
- The most appropriate thoughts of the decision makers can implement in their decision making, which is a multi-level MCA implemented to label and find possible adaptation techniques. The MCA is developed on the basis of expert decision.
5.12 Crop modeling

Crop modeling is a smart agriculture practice which are creative and newly developed tool for dealing risks in Agriculture. Computer system has simulation models and those play important role to predict the data which input through the meteorological stations. Final output with computer readings, the crop management responses and crop yield are forecasted.

“Simulation models” significantly assist the work of better crop development and recommend valid crop management. Models can guide to find out the possible risk of climate variation on future crop yields, climate smart agriculture development and mitigation procedures. Comparable to new management options and suitable genotypes which are important factors for better yield, crop simulation models are essential tools in field experiments to create new crop management approaches. In this point of view, two crop management systems have been introduced and mostly used in world wide.

1. **APSIM (Agricultural Production System Simulator)**
   - Developed at the Agricultural production systems research unit, Australia
   - Stimulate biophysical process in farming systems
   - Links to economic and ecological outcomes of management practices under climate variation
   - APSIM stimulates growth and development of crops, pastures, trees, weeds.
   - It can simulate;
     - Key soil process (Water, N, P, Carbon, pH)
     - Management options (Tillage, sowing, irrigation, fertilization)
     - Surface residues dynamics
     - Soil erosion
     - Cropping system
     - Rotations/following/mixtures
     - Short- or long-term effects (Figure 6).
2. **DSSAT (Decision Support System for Agro-technology Transfer)**
   - This was developed based on crop processes (Figure 7)
   - Integrated the interaction of weather, soil, management and genetic factors
   - Prediction of yields, plant phonologic stages, plant weight, harvest date, water soil quantity, N quantity
   - Current and future prediction, need precise and daily data
5.13 GIS mapping

GIS (Geographical Information System) is a mapping system, used in locations estimation, area determination, geological processing. This technique helps in the estimation and computation of the storm course and flooding associated with hot cyclones. While input data, the study area is describing into detailed mapping graph. It says population allocation, infrastructure and other undertreat resources. For an example below photographs and images show (Figure 9), seashore due to hot cyclones and rising sea levels.
Risk which can be explained by the cumulative study of possible threats and existing situations of the susceptibility. From the GIS mapping, 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, forest and cultivated lands, etc.

Figure 8: Risk Assessment and mapping (Source: IPCC, 2007)
6.0 Small scale farmer adoption to CSA

Smallholder farmers in developing countries, there are opportunities for greater food security and increased their income together with greater resilience which will be more important for adopting climate-smart agriculture than modification opportunities. In the field operations with large machineries, environment will be exposed to greater emission, therefore with the intensive mechanized agricultural operations, the opportunities to reduce emissions will be of greater interest. Many climate smart agricultural systems can be integrated into a single farming system and there would be multiple benefits that can improve livelihoods and incomes.

For example: At the small holder level it will be started with the time limitation, labour constraints, high investment or maintenance costs may exceed the capacity of poor farmers income level and competition for crop residues which may be restricting the availability of feed for livestock and biogas production. Identifying these constraints is important for developing economically attractive and environmentally sustainable management practices that can be adapted by the offering benefits (Table 01).

Table 01: Small scale CSA systems

<table>
<thead>
<tr>
<th>Crop management</th>
<th>Livestock management</th>
<th>Soil and water management</th>
<th>Agroforestry</th>
<th>Integrated food energy systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercropping with legumes</td>
<td>Improved feeding strategies (e.g. cut 'n carry)</td>
<td>Conservation agriculture (e.g. minimum tillage)</td>
<td>Boundary trees and hedgerows</td>
<td>Biogas</td>
</tr>
<tr>
<td>Crop rotations</td>
<td>Rotational grazing</td>
<td>Contour planting</td>
<td>Nitrogen-fixing trees on farms</td>
<td>Production of energy plants</td>
</tr>
<tr>
<td>New crop varieties (e.g. drought resistant)</td>
<td>Fodder crops</td>
<td>Terraces and bunds</td>
<td>Multipurpose trees</td>
<td>Improved stoves</td>
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<td>------------------------------------------</td>
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</tr>
<tr>
<td>Improved storage and processing techniques</td>
<td>Grassland restoration and conservation</td>
<td>Planting pits</td>
<td>Improved fallow with fertilizer shrubs</td>
<td></td>
</tr>
<tr>
<td>Greater crop diversity</td>
<td>Manure treatment</td>
<td>Water storage (e.g. water pans)</td>
<td>Woodlots</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improved livestock health</td>
<td>Alternate wetting and drying (rice)</td>
<td>Fruit orchards</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Animal husbandry improvements</td>
<td>Improved irrigation (e.g. drip)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Dams, pits, ridges</td>
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</tr>
</tbody>
</table>

**Source:** Neufeldt et al, 2011

6.1. Methods to overcome the challenges and to introduce small scale climate-smart agriculture

1. Providing supporting services
   National and government involvements facilitate to local farmers to engage above climate smart practices to follow up and practice to uplift their income generation and food security on the society level.

2. Improving market opportunities and enhancing income generating factors provided by agroforestry system.
   This can be done through improving infrastructure or more locally through establishing cooperatives, creating resources pool to access markets. Most effective ways to reduce a farmer’s susceptibility to climate change is through improving their income.

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3. Farmer’s involvement in the project-planning process.
Fanners’ input should be used to ensure development projects target what is most relevant to local communities and be designed to accomplish agreed goals in the most effective way within the local context.

4. Improving access to knowledge and training.
This has been achieved through the farmer organizations, knowledge dissemination to significantly improve farmers’ willingness to plant more trees for multiple purposes. As the concept of home gardens in each household unit, they fulfill the daily food requirement. This multi-purpose crop managements are reducing the risk of food security.

5. Overcome the barriers of high opportunity costs to land
Smallholder farmers can improve their management systems. This is a key requirement for successful implementation of climate-smart agriculture in developing countries and to-date it has been given little attention. Many improved management practices provide benefits to farmers only after considerable periods of time.

6. Improving access to farm implements and capital.
Payments for carbon sequestration may be an appropriate way of covering the time lag between investing in climate-smart practices and obtaining the environmental and economic benefits.
7.0. Climate Smart Agriculture techniques possible in Sri Lanka.

7.1 Home gardening

- Boundary trees and hedge rows, Multipurpose trees, Nitrogen-fixing trees on farms, Taungya system, live fences
- Improved fallow, Woodlots, Fruit orchards
- CSA strategies used by home gardeners mainly depending on household head educational attainment, farming experience, garden size, and perception of climate change impacts.
- Strategies to improve household food security and income and for mitigating the adverse effects of climate change on agricultural production.
- Home gardeners, introduce new technologies, new varieties and irrigation equipment, soil and water conservation measures, agronomic practices and new planting cycles
- Livestock are increasingly included to improve food and nutrition security, and may contribute to increasing biodiversity
- Home garden (Kandyan home garden (Figure 09), dry zone home garden.

Figure 09: Kandyan home garden
7.2 Soil Management Practices

- Zero or minimum tillage, contour farming, terracing, trash banding (Figure 10)
- Application of soil amendments.
  - Biochar is the carbon rich component, which was produced by the pyrolysis and due to its porous nature, high surface area, cation exchange capacity, it absorbs high nutrient content and reduce the emission to the atmosphere.
  - Increases biological activity and improves the efficiency of nutrient use, which reduces nitrous oxide emissions and increases carbon sequestration

![Figure 10: Soil management practices](image)

7.3 Improved Water Management Practices

- Improved irrigation water channel, micro irrigation, planting pits are mixed with aerated potting mixture and water basins for erosion control.
- Water harvesting and storage, mulching. (figure: 11)
7.4 Crop Management Practices

- Cover crops (Figure 12), crop residues incorporation
- Intercropping with legumes, crop rotation, Allay cropping.
- Cover crops and shade management have helped to overcome heat stress and improve productivity in several production systems.

7.5 Adoption of drought resistant crop varieties

- Drought resistance rice varieties introduced by the Rice Research Institute.
- Other Field Crops (OFC) crops for dry zone cultivation.
7.6 Improved storage and processing techniques
To reduce postharvest losses, drying equipment, storage devices, milling equipment are invented by the Institute of Post-Harvest Technology and the Farm Mechanization Training Centre in Sri Lanka (Figure 13).

Figure 13: Post harvest operations with Rice in Sri Lanka

7.7 Livestock Management Practices

- Grazing land management and pasture improvement practices
- Integrated crop-livestock management
- Breeding for adaptable breeds to the different AERs can enhance the productivity of the systems.
- The sustainable utilization of indigenous animals specifically identified in the animal breeding guidelines of the Ministry of Livestock and Rural Community Development can increase productivity, due to their resistance and or tolerance (e.g. CPRS poultry breed developed for local climatic conditions and feeding regimes), resistance to diseases, and their multipurpose character
(e.g. *Kottukachchiya* goat breed developed as a dual-purpose breed suitable for DZ of Sri Lanka).

![Kottukachchiya goat breed](image)

**Figure 14: Kottukachchiya goat breed**

- Introducing high yielding exotic breeds, and crossbreeds can help to achieve country’s goal to reach 50 % self-sufficiency in milk production by 2015 under a variable climate.

The practices which are an indication of the broad range of CSA practices that have been adopted in different production systems, and at different scales and intensities, in Sri Lanka. Despite the great variety of productivity and adaptation strategies, significantly fewer strategies focus on mitigation.
Figure 14: Selected Practices for Each Production System with High Climate Smartness
8.0 Detailed smartness assessment for top ongoing CSA practices by production system as implemented in Sri Lanka

The assessment of a practice’s climate smartness uses the average of the rankings for each of six smartness categories: water, carbon, nitrogen, energy, weather, and knowledge. Based on the values the ranking, the smartness categories emphasize the integrated components related to achieving increased adaptation, mitigation, and productivity that relate to the pillars of Climate Smart Agriculture (Table 02).

**Table 02: Smartness assessment of CSA practices and production systems**

<table>
<thead>
<tr>
<th>CSA Practice</th>
<th>Climate Smartness</th>
<th>Adaptation</th>
<th>Mitigation</th>
<th>Productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rice (paddy rice: 46% of total harvested area)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seasonal-adapted planting times Low adoption (&lt;30%)</td>
<td>4.2</td>
<td>Efficient use of rainwater and efficient management of rainwater harvested in village tanks.</td>
<td>Reduces GHG emissions such as methane by minimizing periods of flooding. However, supplementary irrigation would be required to ensure water availability but can also possibly lead to higher energy consumption.</td>
<td>Increases productivity and income.</td>
</tr>
<tr>
<td><strong>Changing crop establishment techniques (dry sowing)</strong> Low adoption (&lt;30%)</td>
<td>4.0</td>
<td>Minimizes water use and conserves soil moisture, when combined with minimum or zero tillage.</td>
<td>Promotes carbon storage in soil. Water retention increases, which in turn reduces energy needs for irrigation, reduces inundation, thus reducing GHG emissions</td>
<td>Productivity may be maintained/reduced depending on rainfall availability</td>
</tr>
<tr>
<td>Planting with onset of rains (High adoption (&gt;60%))</td>
<td>Adjusting the cropping calendar by planting with the onset of rains reduces losses due to changing water patterns.</td>
<td>Rainwater supply can reduce energy needs for irrigation.</td>
<td>Increased land and crop productivity per unit of water.</td>
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</tr>
<tr>
<td>Growing in selected agro-ecological regions with long rainy seasons (High adoption (&gt;60%))</td>
<td>Suitable planting areas can reduce crop vulnerability to changing water and climate patterns.</td>
<td>Rainwater supply can reduce energy needs for irrigation.</td>
<td>Increased land and crop productivity per unit of water.</td>
<td></td>
</tr>
<tr>
<td>Organic fertilizers (High adoption (&gt;60%))</td>
<td>Enhances soil quality, water retention and soil functions, increasing the system’s potential to overcome climate shocks.</td>
<td>Reduces use of nitrogen fertilizer, thus reducing nitrous oxide emissions.</td>
<td>Enhanced product quality and increased income.</td>
<td></td>
</tr>
<tr>
<td>Mulching and thatching (High adoption (&gt;60%))</td>
<td>Improves soil’s retention of nutrients and combats erosion. Conserves soil moisture and promotes maximum use of soil residual moisture. Controls weed.</td>
<td>Reduces use of synthetic fertilizer and related GHG emissions. Increases carbon storage in soils.</td>
<td>Increased productivity per unit of water consumed.</td>
<td></td>
</tr>
<tr>
<td>Coconut (17.5% of total harvested area)</td>
<td>Cover crops (live mulches) Low adoption (&lt;30%)</td>
<td>3.7</td>
<td>Leguminous cover crops reduce the requirement for nitrogen fertilizer of the crop and enriches soil fertility.</td>
<td>Ploughing in cover crops promotes carbon storage in soil.</td>
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<td>----------------------------------------</td>
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<td>--------------------------------------------------------------------------------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td>Micro-irrigation Low adoption (&lt;30%)</td>
<td>3.5</td>
<td>Ensures water availability</td>
<td>No significant benefits. Inefficient use of fuel pumps may increase the system's contribution to GHG emissions.</td>
<td>Increased land and crop productivity per unit of water.</td>
</tr>
<tr>
<td>Rearing and conservation of indigenous cattle Low adoption (&lt;30%)</td>
<td>3.2</td>
<td>Local breeds can present greater resistance to diseases and heat stress.</td>
<td>Contributes to reductions in GHG emissions and energy when integrating the practice with techniques related to feeding and manure management.</td>
<td>Reduces production costs by reducing external inputs.</td>
</tr>
<tr>
<td>Composting and biogas production High adoption (&lt;30%)</td>
<td>3.1</td>
<td>Increases system's resilience to climate shocks.</td>
<td>Reduces the use of nitrogen fertilizer, thus reducing nitrous oxide emissions.</td>
<td>Increased land productivity, product quality and income.</td>
</tr>
<tr>
<td>Activity</td>
<td>Adoption Rate</td>
<td>Score</td>
<td>Description</td>
<td>Benefits</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>----------------</td>
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<td>----------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Chicken</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Waste management (compost production)</td>
<td>Low (&lt;30%)</td>
<td>3.4</td>
<td>Improves organic matter usage in crop production (integrated crop-animal systems) and minimizes use of chemical fertilizers.</td>
<td>Reduces the use of nitrogen fertilizer, thus reducing nitrous oxide emissions.</td>
</tr>
<tr>
<td>Rearing adaptive breeds</td>
<td>Low (&lt;30%)</td>
<td>3.1</td>
<td>Increases system’s resilience to climate shocks.</td>
<td>Contributes to reductions in GHG emissions and energy when integrating the practice with techniques related to feeding and manure management.</td>
</tr>
<tr>
<td><strong>Home gardens</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agroforestry</td>
<td>High (&gt;60%)</td>
<td>4.4</td>
<td>The inclusion of tree crops for shade reduces heat stress on the soil.</td>
<td>Increases in carbon sequestration and storage.</td>
</tr>
<tr>
<td>Agroforestry (crop–livestock integration)</td>
<td>Low (&lt;30%)</td>
<td>3.9</td>
<td>Improves use of organic matter in crop production (integrated crop animal)</td>
<td>Reduces burning of fossil fuel, contributing to minimizing GHG emissions.</td>
</tr>
</tbody>
</table>
Vegetables | Micro-irrigation Low adoption (<30%) | 3.7 | Ensures water availability. | Use of efficient fuel pumps may be required to avoid increases in energy consumption. | Increased land and crop productivity per unit of water.

**Source:** World Bank; CIAT. 2015.
9.0 Institutions and policies for CSA

Following are few policy addresses and implications of CA+SA in Sri Lanka:

1. Lanka was amongst the first 50 countries to approve the United Nations Framework Convention on Climate Change (UNFCCC) in 1993.
2. It became a signatory to the Montreal Protocol and the Kyoto Protocol in 2002.
3. Domestically, Sri Lanka’s discuss the effect of climate change on food security with special emphasis on vulnerable groups under the UNFCCC in 2000 and 2011.
4. Sri Lanka will continue to support these commitments with a more comprehensive National Adaptation Plan (NAP), climate change issues are fixed in different sectorial policies in Sri Lanka.
5. These policies are assigned for adaptive and mitigation capacities of the country, though at different priority levels. The main national strategies concerning CSA include:
   - Sri The National Environmental Policy (NEP), 2003.
   - The National Climate Change Policy (NCCP), 2012.

6. There are two policy and planning instruments that directly address climate change in Sri Lanka, but they don’t have direct reference to mitigation in the agriculture, livestock, and fisheries sectors.
   - The National Policy on Air Quality Management (NPAQM)
   - Draft National Policy on Clean Development Mechanism (NPCDM)
7. In 2006, Strategic Environmental Assessments (SEA) for all policies, plans, and programmes prior to implementation, several sectoral directives have been created to guide the adoption CSA action plans.

- National Agriculture Policy (2007)

8. In addition to that, Sri Lankan government created separate policy that consider adaptation and mitigation strategies. The Climate Change Secretariat (CCS) within the Ministry of Mahaweli Development and Environment (MMDE) is assigned with facilitating, formulating, and implementing climate-related projects at the national level.

9. Several public entities contribute to climate change research that supports adaptation and mitigation practices.

- In 2000, a GHG inventory was prepared by MMDE, and an update is currently under preparation.
- In 2000, Centre for Climate Change Studies (CCCS) was established under the Department of Meteorology (DOM) to conduct research, monitor climate change, and provide the general public with current information on climate change-related issues.
- In 2007, the Ministry of Environment identified the nation’s main challenges to implementing the UNFCCC and tasked appropriate ministries with strengthening the capacities that fall within their respective sectors.
- In 2014–2018, The Disaster Management Centre (DMC) has been mandated to formulate national and local-level disaster risk management programmes and align them with sector development programmes, starting with the Sri Lanka Comprehensive Disaster Management Programme (SLCDMC)
• The DOM - provide weather and climate forecasts and disseminate them to the general public
• Department of Irrigation (DOI) - water management in all agriculture systems.

10. Collaborations between mitigation and productivity are achieved through research, development, and extension programmes for Sri Lanka’s main production systems.

11. For the plantation crop sector, various institutes under Ministry of Plantation Industries (MPI) focus on CSA for specific crops,
   o Tea Research Institute (TRI),
   o Coconut Research Institute (CRI),
   o Rubber Research Institute (RRI).
   o Other export crops - Department of Export Agriculture (DEA) and extension services from the Department of Agrarian Development (DAD).
   o The seasonal food crop - Department of Agriculture (DOA) of the Ministry of Agriculture (MOA),
   o Sugar sector research and development - Sugarcane Research Institute (SRI).
   o The Department of Animal Production and Health (DAPH) and the Veterinary Research Institute (VRI) - conservation of indigenous livestock germplasm for the purpose of future breeding that takes into account climate change.
   o The faculties of agriculture of Sri Lankan universities are responsible for higher education, training, and research in CSA techniques.
10.0 Worldwide FAO’s contribution to climate-smart agriculture

Climate Smart Agriculture concept emerged from 2010. International agencies such as United Nations Food and Agriculture Organization (FAO) and World Bank are working for it to evolve a road map. The FAO discussed strategies needed for climate-smart agriculture.

FAO has decades of experience in promoting agricultural practices and policies that ensure food security while safeguarding the natural resource base for future generations.

Agriculture policies,
- for achieving food security and improving livelihoods.
- effective combination of sustainable agriculture and climate change policies
- boosting green growth, protect the environment and contribute to the eradication of hunger and poverty.

FAO works on;
- increasing the agricultural productivity,
- ensuring that the natural resources are not exploited or depleted.
- Supporting countries in transitioning to climate-smart agriculture in a number of ways.

10.1 Ongoing initiatives

10.1.1 FAO-Adapt
FAO-Adapt: Organization-wide framework programme
Services

- General guidance and provides principles, priority themes, actions and implementation support to FAO’s activities related to climate change adaptation.
- Promoting activities in agriculture, forestry and fisheries that enhance sustainable production while strengthening the resilience of agricultural ecosystems to cope with the impacts of current and future climate change.
- Improving the capacity of Member Nations to implement climate change adaptation measures and assist them in making climate-smart decisions regarding agricultural practices.
- Supporting planning and decision making, a number of methodologies and tools have been developed by FAO.

10.1.2 The MICCA Programme

The Mitigation of Climate Change in Agriculture (MICCA): knowledge base on climate change mitigation in agriculture

Services:

- Conducting life cycle analyses of agricultural production chains, analyzing global mitigation potentials and costs, and reviewing opportunities and obstacles for mitigation at the farm level.
- Decision-making by analyzing policy options and farmer decision-making processes, and by supplying information to the UNFCCC negotiations.
- Generates reliable data by addressing the large variations and gaps in data related to greenhouse gas emissions from agriculture and forestry and strengthens countries’ capacity to carry out their annual greenhouse gas inventories.
• Produce quantifiable evidence that climate-smart agricultural practices can mitigate climate change, improve farmer livelihoods and make local communities better able to adapt to climate change.

10.1.3 The UN-REDD Programme
The UN-REDD Programme: is a collaborative partnership between FAO, the United Nation Development Programme (UNDP) and the United Nations Environment Programme (UNEP)

Services:
- Supports countries to reduce emissions from deforestation and forest degradation (REDD)
- Implement a future REDD+ mechanism, includes the conservation, sustainable management of forests, and the enhancement of forest carbon stocks.
- Forests and agriculture are intimately linked. Agriculture is a key driver of deforestation in many countries.
- Protect the natural resource base, realize mitigation potentials and enhance output from production systems.
- Forestry and agriculture sectors need to coordinate their planning, policies and strategies, using a landscape approach.
10.1.4 FAO’s Forest and Climate Change Programme

The Forest and Climate Change Programme strengthen national and international actions on forests and climate change adaptation and mitigation.

**Services:**

- Raises awareness, strengthens technical capacities, creates enabling policy environments for action and encourages cross-sectoral and landscape approaches to climate change.
- Work with countries and other partners to develop two specific tools to assist countries mainstream climate change into the forest sector at both the policy and forest management levels.
- 1st tool: ‘Climate Change for Forest Policy Makers’
  - To assist forest policy makers, develop strategic goals and operational actions to integrate climate change into forest policy, legislation, governance arrangements and institutional frameworks.
  - Enhances capacity, research, information, communication and financing in forests and climate change.
- 2nd tool
  - Assist forest managers adjust forest management practices to improve climate change adaptation and mitigation.
  - Relevant to all forest types, all management objectives and all forest managers.

10.1.5 FAO’s Fisheries and Aquaculture Climate Change Programme

The Fisheries and Aquaculture Climate Change Programme:

- Supports Member States and partners
- Adapt and mitigate the impacts of climate change for fisheries, aquaculture and aquatic ecosystems, through policy development, exchanges of knowledge, normative outputs, practical demonstrations and capacity building.

**Services:**

- Supporting global, regional and local climate change action, partnerships including public and private sectors, community groups and non-governmental organizations.
- Construction the knowledge base for local, national and international policy development for climate change and the fisheries and aquaculture sector to raise awareness of the importance of the sector with respect to climate change mitigation and adaptation.
- Identifying and implementing climate change mitigation actions for the fisheries and aquaculture sector at the global, regional and national levels
- Promoting effective climate change adaptation strategies within the fisheries and aquaculture sector
- Developing frameworks at the global, regional and national levels and identifying resources to support prioritized actions at all levels
- Lesson-learning and capacity-building processes with partners - establish more effective climate change responses through specific tools, including the development of strategies and best practices.
- Prepare communication strategy for climate change mitigation and adaptation for a range of audiences and outlining a coordinated approach to global planning and feedback.

**10.1.6 FAO Framework Programme**

FAO Framework Programme - Disaster Risk Reduction for Food and Nutrition Security
Services:
- Supporting countries by reducing vulnerability to crises, threats and emergencies is a corporate priority of FAO.
- Work on disaster risk reduction (DRR) promotes better awareness to the increasing impacts of climate variability, change and extreme events at regional, national and local levels.
- Advises on integration of disaster risk reduction measures for food and nutrition security into policies, programmes and interventions.

FAO’s new Disaster Risk Reduction Framework Programme:
- Figures on existing DRR initiatives, good practices and technical capacities to assist countries
- Design and implementation of enhanced disaster risk reduction for food and nutrition security and agriculture.
- Longer-term time frames and encourages a programmatic and people centered approach to report DRR for food and nutrition security.

DRR framework’s key objectives:
- institutional capacity development;
- food and nutrition security information and enhanced early warning systems;
- better preparedness for disaster response
- Building resilience of ecosystems and livelihoods to threats and disasters with good practices, processes and technologies in farming, fisheries, forestry, and natural resource management.
11. Bibliography


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