Effects Of Climate Change On Agriculture And Its Mitigation Through Climate Smart Agriculture Practices In Nepal

Article · October 2020

DOI: 10.26480/trab.01.2020.47.51

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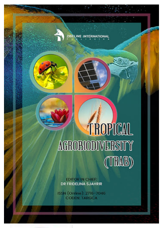
ZIBELINE INTERNATIONAL PUBLISHING

ISSN: 2716-7046 (Online)
CODEN: TARGCA

Tropical Agrobiodiversity (TRAB)

DOI: http://doi.org/10.26480/trab.01.2020.47.51



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REVIEW ARTICLE

EFFECTS OF CLIMATE CHANGE ON AGRICULTURE AND ITS MITIGATION THROUGH CLIMATE SMART AGRICULTURE PRACTICES IN NEPAL

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ARTICLE DETAILS

Article History:

Received 08 August 2020
Accepted 09 September 2020
Available online 05 October 2020

ABSTRACT

Climate change has caused serious effect on agriculture production. The global population is increasing and to meet their demand for fuel, food, and fiber, Farmer should adopt sustainable agriculture practices which provides resilience to climate change and uplifts the farmers' livelihood. Climate-smart agriculture practices are taken as eco-friendly practices that help to enhance production sustainably with minimum effect on resources and environments. These practices include No-tillage, reduced tillage, Intercropping, integrated pest management, Rainwater harvesting, use of information and communication technology, etc. As women are an integral part of agriculture production and are more vulnerable to climate change, the Gender-responsive approach needs to be addressed which helps to close the gender gap in agriculture. Nepal, as a vulnerable country in terms of climate change, is adopting different programs and policies at the national and local level to tackle climate change. Climate-smart villages(CSV) in Nepal are practicing different CSA practices at the farm level to secure foods and livelihoods.

KEYWORDS

Climate change, Climate smart Agriculture(CSA), Climate smart villages(CSV)

1. INTRODUCTION

Climate change is defined as a change of climate over time as a result of natural variability or human activity (IPCC, 2007a). The temperature will rise between 1.8°C and 4°C in an average at the end of the twenty-first century globally (IPCC, 2007b). World's population will increase by one-third by 2050 (FAO, 2009a). As per FAO, production should increase by 60 percent by 2050 to meet expected demands for food and feed (Conforti, 2011). In terms of climate change, Nepal ranks as the fourth most vulnerable country (Dangal, 2012). Nepal has three agroecological zones endowed with various agrobiodiversity and farming systems (Gauchan and Shrestha, 2015). The temperature has increased at a rate of 0.06°Cper year in an average with frequent problems of drought, severe floods, and landslides (Malla, 2008). Agriculture, the backbone of Nepalese economy depends upon monsoon rainfall but due to limited irrigation facilities and changing weather conditions, there is a decline in agriculture productivity (Bhujel and Ghimire, 2006). Thousands of hectares of farmland are fallow because of delayed monsoon and inadequate water supply (Regmi and Adhikari 2007). Climate change adversely affect the agroecosystem, increase the risks of pest and diseases and alter the nutrient and soil moisture cycles (Fuhrer, 2003; Jones and Thornton, 2003). It will affect food availability, access to food, the stability of food supplies, and food utilization (FAO, 2006). This will harm livelihoods and food security (Wheeler and Braun, 2013). Altogether impacts of climate change on agriculture are expected to be negative which menace global food security (Mendelsohn and Williams 2006). Food, fiber, or fuel demands continue to increase globally due to population growth but limited additional land is available for agricultural expansion. The livelihood of farmers should be upgraded at the farm level by implementing different strategies to manage climate risk (McCarthy et al., 2016).

Both natural and human systems should be adjusted to limit the damage caused by climate change and to exploit opportunities (Kropp and Scholze, 2009). More sustainable farming systems should be identified to secure sustainable livelihoods and improve disaster resilience (FAO, 2010). Climate-smart agriculture (CSA) is a strategy to transform and reorient the agriculture system under new climate change (Lipper et al., 2014). Climate-Smart Agriculture (CSA) includes water-smart practices, soil-smart practices, crop-smart practices information and communications technology, and crop and livestock insurance (CIAT, World Bank, CCAFS, and LI-BIRD, 2017). Climate-smart agriculture practices help to increase food production sustainably, strengthen farmer resilience to adapt to changing climate, and reduces emissions of greenhouse gases (Lipper et al., 2014; Aggarwal et al., 2108). Developing countries contribute 74% of total emissions from agriculture (Von Koerber and Kretschmer, 2006). Almost emissions from agriculture can be mitigated through soil carbon sequestration(89%) (Fischer et al., 2006a, FAO 2009). CSA consists of practices, institutions, and policies that are used in climate change conditions and these may be unknown to farmers (Papuso and Faraby, 2013). We should enlarge the base, empower local institutions, assist technical policy, share solutions, and combine new financial areas and policies to make climate smarter in reality (FAO, 2015). Climate-Smart agriculture practices are the new agricultural technologies and practices at the farm level (Scherr et al., 2012).

Conservation agricultural practices such as minimum tillage, different methods of crop establishment, nutrient and irrigation management and residue incorporation can be considered as climate-smart agriculture practices as it improves crop yields, water, and nutrient use efficiency and reduce GHG emission from the agricultural fields (Branca et al., 2011b; Jat et al., 2014; Sapkota et al., 2015).

Quick Response Code	Access this article online	
	Website: www.trab.org.my	**DOI:** 10.26480/trab.01.2020.47.51

Cite The Article: Subedi N and Poudel S (2020). Effects Of Climate Change On Agriculture And Its Mitigation Through Climate Smart Agriculture Practices In Nepal. *Tropical Agrobiodiversity, 1(1): 47-51.*

2. CLIMATE SMART AGRICULTURE PRACTICES

2.1 Soil Smart

Soil provides food and fiber for an increasing population. Soil properties such as soil formation, development, and fertility are affected by climate change factors such as moisture, temperature, and carbon dioxide which results in global food insecurity (Navneet Parik, 2017). No-tillage (NT) preserves soil organic carbon concentration especially on topsoil and mitigates the negative impacts on soil quality (Kern and Johnson, 1993; West and post, 2002). It helps to reduce fuel, labor, and machinery costs, and conserves soil moisture, minimizes erosion losses (Lal et al., 2007). Water use efficiency was significantly higher in ZT (Su et al., 2007). Zero tillage increased the activity of surface-feeding earthworms and the presence of numerous macrospores and inter-pedal voids results in higher infiltration (Kemper et al., 1987).

Exchangeable Ca, Mg, and K, were significantly higher in the surface soil under NT compared to the plowed soil (Ismail et al., 1994; Rahman et al., 2008). Sloping Agriculture Land Technology (SALT) an approach for soil conservation and food production in sloping lands helps to conserve soil and water, enriches the soil, stabilizes slopes, enables farming on slopes, and gradually forms bio-terraces (Pratap 1998, Grogan et al., 2012). Agro-forestry, agri-horticultural and agri-pastoral systems reduce erosion and runoff, maintain soil organic matter, improve soil physical properties, and increase nitrogen fixation and promote efficient nutrient cycling (Nair, 1984).

2.2 Crop Smart

Intercropping systems provide ecological sustainability, the stability of outputs, greater productivity, resilience to disturbance (Vandermeer, 1989). Planting of peas and cereal crops in an intercropping system reduce weed infestation due to their better competitive and higher resource use efficiency than as a sole pea crop (Hauggaard-Nielsen et al., 2001, 2006). Green manuring, climate-smart agricultural practices avoid external inputs and resources which is suitable for smallholders (Gurung et al., 2017). Mulching saves water and labor costs (Subedi and Basnet, 2016). Application of jholmal increases crops yields as a result of the faster supply of nutrients which helps in plant growth by overcoming temporary nutrient deficiencies (Gajjela, 2018). Growth promoting bacteria in jholmal increases nitrogen fixation in soil, induce growth hormone production, and control pathogens to enhance crop growth (Rakesh et al., 2017). Organic farming maintains soil fertility by bio-intensive nutrient management, recycling of agricultural wastes, vermicomposting, avoidance or reduction of external inputs, use of natural forms of pest management, and weed control (Goldsmith and Hildeyard 1996; Hansen et al., 2006). Alternate wetting and drying reduces irrigation amount by about 30% and can result in maintaining the yields as that of flooded rice (Bouman et al., 2007). Drought-tolerant varieties of rice, wheat, maize, and legumes can yield even in some fluctuation of moisture under stress environment (Paudel, 2012).

2.3 Water Smart

Water, the primary medium through which climate change impacts will be felt by people, ecosystems, and economies' (Stuart-Hill et al., 2012). Demand for safe drinking water is increasing due to increased population, industries, intense farming, climate change, and more consumption of potable water (Bakkenes et al., 2002). Rainwater harvesting system emerges as an alternative solution to mitigate water scarcity (Patil and Mali, 2013). Globally; rainwater harvesting is being used in improving the food security situation, encourage farmers to diversify their enterprises, creates additional sources of water, and support the conventional water supply systems (Maume, 2014). The efficiency of water use is extremely high in drip irrigation as it reduces the evaporation, conveyance, and distribution losses of water (Dhawan, 2002; INCID, 1994; NCPA, 1990). Fertigation helps in the uniform application of nutrients to the root region and ensures higher and quality yield along with savings in time and labor (Singh, 2002). Fertigation results in inefficient use of water and nutrients and also helps in the synergism of their simultaneous availability to plants. The additional advantages of fertigation are saving energy and labor, convenient use of soluble fertilizers, and controlled supply and monitoring of water and nutrients (Imas, 1999).

2.4 Livestock Smart

Livestock contributes up to 18% of global greenhouse gas emissions (Thornton and Herrero, 2010). Among these, one third is due to land-use change associated with livestock production, one third due to nitrous oxide from manure and slurry management, and roughly 25% is attributed to methane emissions from ruminant digestion. Fluctuating feed prices, habitat changes, expansion of vector-borne diseases in warm climates, impaired reproduction, pasture quality, and availability and physiological heat stress are the challenges faced by the livestock sector due to climate change (Opio et al., 2013; Thornton et al., 2009). Greenhouse gas emissions can be reduced by improving feeding techniques which can be done by producing more from fewer animals with less feed (Blummel et al., 2010). Pasture land can be improved by Improve of vegetation by planting high productivity, drought-tolerant, and deeper rooted fodder grasses and/or legumes (Branca et al., 2011). Livestock insurance that is weather-indexed may also be effective where preventative measures fail (Skees and Enkh-Amgala, 2002). Agroforestry is important for carbon sequestration improved feed and consequently reduced enteric methane and buffer the farming systems against hazards. Shade trees reduce heat stress on animals, improve the supply and quality of forage, which can help reduce overgrazing and curb land degradation (Thornton and Herrero, 2010). Manure application practices reduce N2 O emissions whereas Improved livestock diets, feed additives, can substantially reduce CH4 emissions from enteric fermentation and manure storage (FAO, 2006a). Crop residues can represent up to 50 percent of the diet of ruminants in mixed farming systems (Herrero et al., 2008).

2.5 ICT Smart

With a pluralistic approach, telephone, television, printed media radio, internet networks contribute a lot to enhance agriculture production (Singh, 2014). ICTs initiative in agro-advisory services that are applicable in Nepal are telecommunication initiatives (farmer call center), Media initiatives (KrishiSamachar, KrishiKaryakram on television and FM radios broadcasting information related to contemporary issues and technologies in agriculture), Printed media (Krishi diary, Bimonthly magazines, booklets and pamphlets, KrishakPana in national magazines like Kantipur), Internet-based initiatives (Smart Krishi, IBA Krishi, mobile applications and other agriculture online portals of DoA, AICC providing information related to agriculture) (Das, 2016). Smart Krishi provides authentic information from initial planning to post-harvest techniques and also about agro-entrepreneurship free of cost (Regmi, 2016). ICT makes the framer more inventive and capable which helps in reducing risk and uncertainties among farmers (Abraham, 2007). Mobile applications play a positive role in technology transfer in terms of cost-effectiveness and solving field-based problems of farmers (Wankhade et al., 2011).

2.6 Gender Smart

Women are more affected than men from climate change (Quisumbing et al., 2017). Women play a significant role in the field preparation sowing to harvesting, livestock management, and post-harvest activities. Gender gaps need to be addressed in terms of access to resources, productivity, and vulnerability in agriculture in the wake of climate change (Nyasimi and Huyer, 2017; ChananaNag and Aggarwal, 2018). It is essential to strengthening the ability of women farmers to build resilient farm households, agricultural communities, and food systems (World Bank Group et al., 2015). Agriculture employs 82% of the female workforce in Nepal (World Bank, 2018). Particular needs, priorities, and realities of men and women need to be recognized and addressed in the design and application of CSA (World Bank, FAO, and IFAD, 2015). CCAFS in collaboration with LI-BIRD promotes CSA practices such as solar irrigation, plastic tunnel farming, greywater collection pond, home garden, drip irrigation, and cattle shed improvement among women farmers in multiple villages of Nepal which helps to increase farmers productivity and resilience, mitigate greenhouse gases, and enhance the achievement of food security and development goals (Sherpa et al., 2017). Policies that consider gender issues and needs in terms of climate change are the Climate Change Policy (2067), National Adaptation Program of Action (NAPA), and the National Adaptation Plan (NAP).

Out of 15 agricultural policies, 11 policies identify women in agriculture as a target group for focusing policy and program interventions.

- National Agriculture Research Center (NARC) Promote capacity building efforts of Women.
- National Seed Vision improves income for women in the seed value chain.
- Agriculture Development Strategy target to increase women's land ownership from 10% (in 2010) to 50% by 2035.
- Nepal's Gender Mainstreaming Strategy aims to achieve 50% of women's participation in all agricultural production-related interventions, institutions, and organizations.
- Renewable Energy Subsidy Policy provides an additional subsidy to women-headed households.
- Nepal Agricultural Extension Strategy reduces constraints related to women's mobility, access to information, skills, credit, and services at the local level.

- Irrigation Policy is silent on promoting women-specific measures to increase their access and affordability to irrigation.

3. National policies and programs

Challenges in agriculture production due to climate change can be sovled through institutional and policy support.Innovative institutional arrangementis required to promote policy implementation. Government of Nepal is also adopting different policies and programmems in the field of climate change and agriculture that are;

- Disaster Risk management strategy,2009
- National Adaptation Program of Action (NAPA) 2010
- Climate Change Policy (2011)
- Environment Friendly Local Governance 2013
- Nepal Biodiversity Strategy and Action Plan 2014-20
- Agro-biodiversity policy,2014
- Irrigation policy,2014
- Low Carbon and Economic Development Strategy (LCEDS) 2014
- Land use policy,2015
- Nature Conservation: National Strategic Framework for Sustainable Development 2015-2030,
- Agriculture Development Strategy (ADS) 2015
- Local Adaptation Programme of Actions (LAPAs)
- Draft Intended Nationally Determined Contributions (INDC) 2015
- Nepal National REDD Strategy 2018

4. Climate-smart villages in Nepal

Consultative Group for International Agricultural Research (CGIAR) and Agriculture and Food Security (CCAFS) is implementing a climate-smart village (CSV) approach in Asia, Africa, and Latin America (Aggarwal et al., 2013). CSV approach is a part of the agriculture research-for-development agenda which addresses climate change challenges for food security (Campbell et al., 2016). Some of Climate-smart village, problems, and farmers adaptation to different climate-smart agriculture practices in Nepal are;

Districts	Problems	CSA practices
Bardiya (Deudakala, Mohamamdpur, Belawa)	An increase in average temperature limits the fruiting of solanaceous crops. Dry soils inhibit crop development, reduce grain filling period, Decrease production of winter crops, fodder, flush of new plants. Unable to cultivate crops in time due to delayed onset of rainfall. Incidence of flood accumulated sand in agriculture land and damage cultivated land.	Use of a drought-tolerant variety of rice (sukha - 1,2,3) and early variety hardinath. Using water from a small stream and groundwater. Plowing, planking, burning of infected plants, Use of disease-resistant variety (abarodhi)of chickpea. Switch cropping from rice to banana due to high infestation of root cutting termite. Cultivation of dwarf tolerant varieties of crops (maize, rice, wheat)to adapt storm.
Dang(Rampur,Hekuli,Dhanauri)	An increase in temperature causes wilting. An infestation of insect pests such as borer, powdery mildew. The decrease in rainfall affect panicle initiation, forced early maturity of crops, low production of late-planted rice, the emergence of unwanted weeds. Delay onset and early end of monsoon, riverbank cutting due to flood, landslide	Construction of Gabion walls and no house construction in the vicinity of the river. Plantation of trees, adoption of alternative crops such as linseed and construction of water harvesting pond, boring and lifting irrigation water by a solar pump.
Nawalparasi (Narayani, Rajahar, Tamsariya)	Increase in temperature An infestation of diseases, Increase no of hot days , decrease in rainfall; unable to raise seedbed in time	Organic farming and application of cattle urine, neem leaves, and titepati. filed sanitation and burning weed. Gabion, afforestation, bamboo and Amriso cultivation for flood, changing planting time to overcome flood, cultivating drought-tolerant varieties
Mahottari(Sarpallo,Hattisarwa,Rajbas)	Insect infestation prominent in mango production, very hot days hampered rice yield, the extra cost of water inputs, dry days affect cattle raising with sunstroke, and less milk production	Drought is adapted through irrigation canal, drip irrigation, and cultivating a drought-resistant variety of rice mainly Sukhha-4, bioengineering, damp construction, and afforestation.
Gorkha(Ghyachock,Bhulmichock)	Increase the incidence of insect pests, rainfall, dry days, floods landslide affect livelihood.	Due to dry days, farmers have no option than leaving the land fallow. Soil erosion and changed rain patterns cause difficulty in decision making.

(Adhikari et al, 2016)

5. Conclusion

Climate change is inevitable. Irregular rainfall patterns, drought, storm, erosion, landslides are the major challenges faced by the farmers of Nepal. These problems can be minimized by the help of climate-smart agriculture practices mostly using locally available resources and ideas. The government has developed several policies and plan to tackle climate change but these are not implemented correctly. As climate change has a serious effect on agriculture production, in the long run, proper plans and policies about climate change should be made and implemented effectively. Therefore, it is high time to think and implement sustainable practices for the betterment of farmers, the environment, and food security.

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