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REVIEW ARTICLE

CLIMATE SMART AGRICULTURE FOR ADAPTING AND MITIGATING IMPACTS OF CLIMATE CHANGE: GLOBAL AND NATIONAL SCENARIO - A REVIEW

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ABSTRACT

This study unravels the effects of the change in climate on Nepal's national and regional trends. It discusses the alarming rise in global temperature, evidenced by data from 1850 to 2020. It underscores the undeniable warming trend and unprecedented changes observed across various climate indicators, including atmospheric and oceanic warming, diminishing snow and ice reserves, rising sea levels, and the resulting surge in natural calamities—the narrative shifts to the national context, highlighting Nepal's geographical vulnerability due to its diverse topography. The country's susceptibility to climate change is demonstrated by its high ranking in global climate risk indices. The country's Second National Communication (SNC) identifies sectors like energy, agriculture, water resources, forestry, and biodiversity as particularly at risk. The implications for the agriculture sector are profound, as changing precipitation and temperature patterns disrupt crop cycles, trigger pest outbreaks, and jeopardize food security. A 1°C temperature increase is estimated to lead to a 4.2-ton reduction in rice production. To combat these challenges, Nepal has established plans and policies to adapt to the changing climate. The 2019 Climate Change Policy places a strong emphasis on social inclusion, gender equality, and sustainable farming methods. Ambitious goals of climate resilience and zero net emissions by 2045 are outlined in the Long Term Strategy (LTS) and the Second Nationally Determined Contributions (NDC). The National Adaptation Plan (NAP) provides a comprehensive framework for sector-specific adaptation measures, focusing on programs that enhance agricultural productivity, genetic resource conservation, water management, and climate services. The Local Adaptation Plan for Action (LAPA) extends these efforts to grassroots levels, integrating climate adaptation into local planning and development. The paper underscores the "triple-win" approach of climate-resilient agriculture (CRA) – enhancing productivity, building resilience, and sequestering carbon. Various CRA practices, including soil health improvement, crop variety adaptation, water management, agroforestry, and pest control, are discussed in the context of Nepal's climatic challenges. These strategies paves a path for the agricultural sector to mitigate climate risks and contribute to climate change mitigation and sustainable development goals. The paper focuses the urgent need for adoption of climate-resilient agricultural practices to secure food systems and safeguard livelihoods against the escalating impacts of climate variability.

KEYWORDS

National Adaptation Plan, Local Adaptation Plan, Climate Change Policy, Emission

1. INTRODUCTION

Climate change is the outcome of both large-scale changes in weather patterns and the global warming effect caused by anthropogenic (human-caused) emissions of greenhouse gases (Stocker et al., 2013). The yearly average worldwide surface temperature between 1850 and 2020 shows an increasing trend in global average temperature (Figure 1). Unquestionably, the climate system has been warming since the 1950s, and many of the changes that have been detected are thought to be unprecedented over the course of decades or even millennia. Global warming of the ocean and atmosphere, a reduction in snow and ice supplies, and an increase in sea level have all been seen (IPCC, 2014). Consequently, natural calamities like intense storm, heatwaves, droughts, massive forest fire, floods, emerging infectious diseases, triggered by CO2 emission has been extensively detectable since last decade.

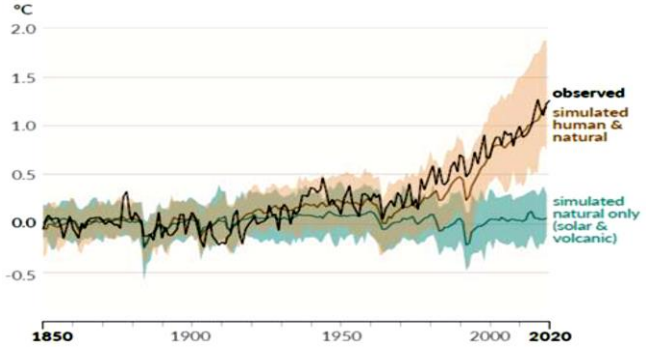

Figure 1: Variations in the worldwide surface temperature on an annual average, as determined and forecasted by a combination of natural and anthropogenic factors. (both 1850-2020)

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Source: Figure SPM.1, Panel (b) (IPCC, 2021)

2. Climate Change: Global Scenario

In recent years, the Climate Change (CC) phenomenon has been observed in various parts of the globe affecting the entire climatic system of the planet. The likelihood of exceeding the 1.5°C global warming threshold in the upcoming decades is predicted by the IPCC's most recent assessments, which show how quickly global warming has been increasing. (IPCC, 2021). Although the global average in temperature change if 1.5° does not pose as a large change, but the regional, temporal impact are largely different from it. There will be more heat waves in broader areas, longer warm seasons, and shorter but more intense cold seasons as a result of the 1.5°C global warming. The global warming warning of 2°C is likely to be reached in the absence of bold interventions. Heat extremes may therefore surpass boundaries of tolerability that are crucial for agriculture and human health. Changes in winds, snow and ice, coastal regions, and oceans will also occur, along with variations in moisture and dryness.

The global temperature is already at 1.1°C above 1880. The years have been hottest in the past 2,000 years while the 19 of the hottest years has occurred since year 2000 AD (NASA/GISS, 2022). Arctic sea extent is decreasing at tremendous rate of 13% per decade since 1979, with lowest on 2012. Yearly, 427 billion metric tons of polar sheets are melting resulting into the rise of sea level at the rate of 3.4 millimeters per year (NASA, 2022) The Hindu-Kush-Himalaya region – also known as third pole, has seen the similar impact due to global warming with accelerated melting of snow and glacial retreat. By the end of the century, HKH glaciers are predicted to lose between 30 and 35 percent of their volume under the 1.5° scenario, which could reach up to 65% given the current emission patterns (Kraaijenbrink et al. 2017; Immerzeel et al., 2020; Kraaijenbrink et al., 2017). More than 80% of the glaciers in western China have receded, losing 4.5% of their total spatial coverage in the last 50 years or more, according to recent research (Yongjian et al., 2015). Temperature and the main glacier feeding the Ganges is retreating more than 35 meters per year, almost twice as fast as it did 20 years ago. The Tibetan glaciers are melting at an accelerated rate; two-thirds may disappear by 2060. The glaciers feeding the Indus have receded by 35–50% since the 1930s (Ramanathan et al., 2008). Moreover, the area covered by Himalayan glaciers has decreased by more than 20% since the early 1960s, according to the U.S. National Aeronautics and Space Administration (NASA) (Rose, 2012). Furthermore, the HKH is also going throughIn South Asia, monsoon rains are likely to increase by 6.4% even as droughts lengthen and occur more frequently – by 5–10 times (ADB, 2021).

In addition to these, numerous natural disasters have occurred in past few years ranging from heat wave in Australia reaching record high of 50.7°C; massive wildfire in California, USA in 2017, 2018 and 2020 covering 1,779,730 ha; extreme North American cold wave that reached Mexico dropping temperature of -4.5°C there, flooding in Europe affecting Germany and Belgium and the devastating drought in eastern Africa.

Thus, climate change impacts, as predicted, has not only been evident, but it is expanding at global reach, impacting larger population, and at higher scale.

2.1 Climate change: national scenario

Geographically, Nepal is a small landlocked country sandwiched between the two growing economic giants China and India. The country stretches over the latitude, however the country elevated from highest Himalaya ranges in northern side to low Terai plains in south. Thus ecologically, the country is very reach in natural resources and biodiversity. Nevertheless, Nepal being the small country, the impact of climate change is varying but large owing to its diversified topography. Nepal is the fourth-most climate-vulnerable nation in the world. According to the Global climatic Risk Index 2020, Nepal ranked ninth among countries most severely affected by climatic disasters between 1999 and 2018. (Eckstein et al., 2021).

The five sectors of Nepal's economy most at danger from climate change are energy, agriculture, forestry, water resources, biodiversity, and health, according to the country's Second National Communication (SNC) to the UNFCCC (2014). (GoN, 2020). Meanwhile the Third National Communication reports indicated that CC would have measurable impact on all eight sectors identified. CC also has economic degradation in several ways it is heavily reliant on climate Recent estimates by the Asian Development Bank showed that by 2050, climate change might cause Nepal to lose 2.2% of its yearly GDP. (The World Bank, 2021).

Among the 75 districts of Nepal, 26 districts are listed among the most vulnerable to the changing climate patterns according to the National Adaptation Programme of Action (Ministry of Environment, 2010). Nepal faced one of the worst forest fires in years which occurred in at least 60 places across 22 of Nepal's 77 districts a year back. It resulted in massive air pollution all across the country which forced to halt schools, commute and even some daily activities. In addition, the precipitation pattern has changed a lot over the last decade.

Agriculture has already been impacted by climate change globally, and if the current trend continues, the effects will only get worse. Temperature and precipitation variations have a significant impact on agriculture. In addition to melting ice that releases water, warmer water expands and causes flooding in low-lying areas and rising sea levels, both of which have an adverse effect on agricultural output (Figure 2). Arable crop impacts are readily interpreted as biological shifts, including variations in the flowering and harvesting seasons, alterations in quality, and relocation of cultivable land. Additionally, it modifies patterns of biodiversity and increases attacks by pests and diseases that impact the agricultural environment as a whole.

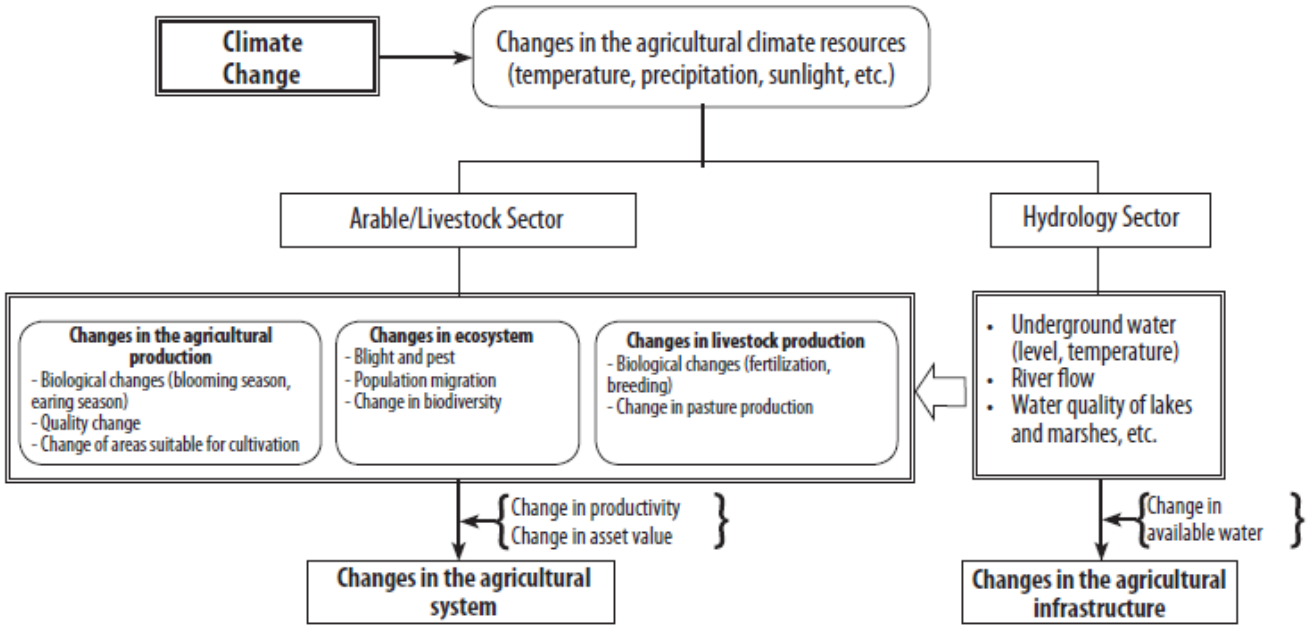

Figure 2: Flow chart showing the results of climate change on agricultural sector

Source: (Kim, Chang-Gil and et al., 2009), Pp.36.

The study by a group of researchers estimated that rice production can reduce by 4.2 tons with a 1°C rise in average summer temperature (Rayamajhee et al., 2020). On addition to that their results showed that extreme rainfall variation hurts productivity (Rayamajhee et al., 2020). Although, the rise in temperature can show some positive impacts such as new crop cultivation in higher altitude areas, extended length of potential growing season, favorable condition for natural decomposing of organic materials as well as more availability of water due to glacial melt (Khanal, 2009; Lohani, 2007; Bartlett et al., 2010; Khanal, 2009; Malla, 2009). In mountain areas, the low temperatures slow down the plant growth which might altered for faster plant growth due to the rising temperature but in long run, the negative impacts is higher compared to the short term benefit. For instance, the physical and chemical properties of soil would be affected, the agricultural production in flat plains will worsen, the precipitation will fluctuate due to the higher temperatures and it could lead to outbreak of new pest and diseases. These long run negative impacts makes it challenging for the farmers to gain higher agricultural productivity. On other hand the high altitude lands will be vulnerable to GLOFs, landslides as well as reduction in water storage in ice caps that affect the population down the stream. The hydrological imbalance can rise – it is predicted there will be increase in discharge in Kaligandaki basin as a result of increased precipitation and in increased temperature which melts off snow - the major source of river water (Bajracharya et al., 2018). Similarly, another study shows that the hydropower generation could decrease by 0.5–13% for different periods (Shrestha et al., 2021).

The report by MOFE predicts the climate of Nepal to be significantly warmer and the pre-monsoon precipitation to be lesser in the future. In the meanwhile, additional extreme events are probably in store for the future, according to indices of climatic extremes linked to temperature and precipitation (MoFE, 2019a). The following significant variations in temperature and precipitation for upcoming periods are listed in the reports:

- Over the long future, it is expected that the average annual precipitation would increase by 8–12%, and in the medium term, by 2-6%.
- Over the medium and long terms, the mean temperature may rise by 0.9–1.1 °C and 1.3–1.8 °C, respectively.
- By 2100, precipitation may rise by 11–23% and the mean temperature may rise by 1.7–3.6 °C.
- All seasons are expected to see an increase in temperature.
- With the exception of the pre-monsoon season, increased precipitation is anticipated. Every season will see a rise in precipitation, with the exception of the pre-monsoon, and the post-monsoon season perhaps
- There will be major impacts on national weather –
- As the frequency of strong precipitation events is likely to rise, extremely wet days (P99) are expected to increase more quickly than very wet days.
- There will probably be fewer wet days in the future. Future warm days and warm nights are predicted to increase by up to twice, while future cold days and cold nights are predicted to decrease. This, along with the intensification of precipitation, is expected to result in an increase in water-related dangers.
- In the future, there is a good chance that the length of warm spells—warm spells lasting at least six days with high maximum temperatures—will rise dramatically while the duration of cold spells is expected to fall.

Nepal ranks 74th in terms of readiness and 46th in terms of vulnerability (NDGAIN, 2019). About 80% of Nepal's population is vulnerable to threats brought on by the environment and climate change.

2.2 Climate change adaptation policies in Nepal

The Ministry of Forest and Environment (MoFE) serves as a focal ministry for communication with the UNFCCC. The climate change actions taken in Nepal are mainly guided by the Environment Protection Act (Environment Protection Act, 2019). The MoFE have also developed the Climate Change policy in 2019 –an update to Climate Change Policy 2011, and Local Adaptation Plans of Action (LAPA) framework 2019. Furthermore, the National Adaptation Plan (NAP) process in 2018-2021 has identified the medium- and long-term adaptation needs of the country. The National Adaptation Programme of Action experience served as the primary reference point for the NAP process (NAPA, 2010). In addition to this, the MoFE has also adopted the GESI, the Climate Change Strategy and Action Plan 2020, and the Climate Resilient Planning and Budgeting Guidelines 2020 (MoFE, 2021). There are various plans and policies that support the adaptation components and activities. The major plans and policies - under which other adaptation plans and strategies are developed, are given below.

2.3 Climate Change policy 2019

According to MoFE, the main goal of this strategy is to create a society that is resilient to climate change in order to support the nation's socioeconomic development (MoFE, 2019). The policy has tackled the mitigation of climate change in agriculture by promoting energy-efficient and low-carbon technologies for production, collection, processing, and storage in the agriculture and animal husbandry sector. Additionally, relevant targets for the revision of the NDC have been established, such as the promotion of energy-efficient and low-carbon technologies for similar purposes. Among the primary areas covered by the policy is agriculture and food security. Using a climate-friendly agriculture system will boost livelihoods, nutrition, and food security. The scope of the policy covers a broad area of programs, plans and action strategies. Cross-cutting issues like Gender Equality and Social Inclusion, Livelihoods and Good, Governance, Awareness Raising and Capacity Development, Research, Technology Development and Expansion, and Climate Finance Management are all taken into consideration in the policy.

2.4 Second Nationally Determined Contributions, 2020

In 2016, pursuant to the Article 4 of the Paris Agreement, Nepal submitted the first Nationally Determined Contribution (NDC) as a commitment towards global efforts in addressing climate change. Nepal's NDC covered a wide range of mitigation and adaptation actions and initiatives that aligns with existing plans and policies of sectorial ministries. The Government of Nepal updated and filed its Second Nationally Determined Contribution (NDC) for the years 2021–2030 on December 8, 2020, as part of the updating process in 2020 (GoN, 2020). This NDC has prioritized formulation and implementation of strategies that captures a clear roadmap on implementation of the NDC for the sectors identified. The Second NDC) has aimed to act on reducing the climate risk by reducing the GHG emissions and climate change adaptation, despite its negligible global emissions contribution. As a part of adaptation component in Second NDC, Nepal must draft and submit an adaptation statement including its goals, requirements for assistance and implementation, plans, and activities. This is the basis for development of the National Adaptation Plan (NAP).

2.5 Long Term Strategy (LTS) 2021

Long term strategy (LTS) has been developed as a guiding document for the NDC's – to see what is future, and to set new targets with changing externalities (Government of Nepal, 2021). The LTS 2021 for Net Zero Emissions (NZE) by 2045 have put up a very ambitious targets along with advance mitigating and adaptation action strategies. The major adaptation actions are focused in agriculture sector. This document is more about exploring the targets and available strategies and their implications. It does not focus on the implementation part. Thus, the cross-cutting issues have not been addressed in this report.

2.6 National Adaptation Plan (NAP)

In September 2015, Nepal initiated the National Adaptation Plan (NAP) process, as mandated by the 2010 Cancun Sixteenth Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change. On October 28, 2021, the Nepalese government's Council of Ministers adopted the National Adaptation Plan (MoFE, 2021). The nine subject categories of the National Climate Change Policy in 2019 are divided into NAP priority initiatives. It has developed a framework to include adaptation at several governmental levels and across industries. Three time periods are designated by the plan's goals:

- long-term adaptation strategic goals to 2050,
- medium-term priority programmes to 2030 and
- short-term priority actions to 2025.

These objectives are meant to help Nepal better incorporate methods and approaches to mitigate climate risk and vulnerability into the design and execution of development projects. The medium- and short-term initiatives are intended to assist the Nepali government in completing the adaptation measures outlined in the Second Nationally Determined Contribution (NDC). The NAP will guide the response to climate change of the three tiers of government, civil society, the corporate sector, and other

players by building a society that is climate-resilient and reducing the possibility that climate change will negatively affect people and ecosystems. Additionally, it will set Nepal on the path to economic development.

These programmes are expected to transform the agriculture sector by building agroecological systems resilience through the enhancement of agricultural productivity, preserving genetic resources, building national capacities and information systems, adopting clean energy, and introducing peasant-friendly climate-induced risk-sharing models.

2.6.1 Major proposed programmes include

- The program on climate-resilient health and hygiene, food and nutrition security, and sustainable agriculture
- Commercial Animal Husbandry (753 Model Demonstration Projects) for Climate Resilient Rural Livelihoods
- Creation of Insurance and a Climate-Induced Risk-Sharing Model That Is Friendly to Communities and Peasants, Along with Its Extension in Livestock and Agriculture
- Enhancing Agriculture Productivity by Developing Climate-Resilient Water Management Systems
- Nepal's Genetic Resource Conservation Program for Climate-Resilient Agriculture
- Promoting Climate Smart Transformative Collective Agriculture in the Mountains and Hills
- Combined Nutrient and Soil Management for Adaptive Agriculture
- Improving Agriculture Information System and Climate Services
- Building the National Capacity of Agricultural Institutions and Professionals (Including Livestock) on Research, Planning, and Implementation of Climate Change Adaptation

2.7 Local adaptation plan for action

As per the suggestions from the participants in the NAPA inception workshop in May 2009, Local Adaptation Plans for Action (LAPA) was formulated for effectively implementating NAPA (Ministry of Environment, 2011). Nepal is the first country to develop Local Adaptation Plans for Action in the world, gaining international recognition, thus, been replicated in countries susch as Pakistan, Kenya, India, Mozambique, Mali, Senegal and Tanzania. The LAPA aims to effectively implement the strategies of NAPA through direct public and local participation and integrating adaptation into the sectorial plans and policies. To integrate climate adaptation and resilience aspects in local and national plans, LAPA was designed and initially tested in Udaypur, Ilam, Kapilvastu, Nawalparasi, Kaski, Rukum, Dadeldhura, Pyuthan, Achham, and Kalikot districts in 2010. To achieve this, main entry points such as forestry, agriculture, water, health and sanitation, watersheds and microfinance education, local infrastructure, disasters and other environment-related areas have been identified.

LAPA aims to climate resilient development by incorporating climate adaptation activities into local and national development planning processes. By boosting adaptable capability and resilience and promoting the cohesive integration of climate change adaptation into pertinent new and current policies, programs, and activities, the LAPA seeks to decrease susceptibility to the consequences of climate change. The process of integrating climate adaptation and resilience into local and national planning is bottom-up, inclusive, responsive, and adaptive, in accordance with the four guiding principles of the LAPA Framework. The goal of developing and implementing local adaptation planning procedures is to address climate-related challenges locally, strengthen resilience, improve local adaptive skills, and integrate these plans into development plans. The planning scales used at the national and local levels to include climate change in their budgeting, scheduling, and decision-making differ significantly. By reaching up the planning process and drawing down resources, LAPA reduces this gap. In order to effectively execute the most urgent and immediate adaptation demands, which are prioritized in NAPA, LAPA also offers a method for mainstreaming local adaptation needs and capacities into development planning.

2.8 GESI – a crosscutting matter in Adaptation plans

The accessibility, the reach and exploitation of the resources vary accordingly to place, people and knowledge as well. The use of the resources and the ability to respond innovatively to adverse climate impacts differentiate women and men from different social contexts, income groups and geographies different in terms of their ability to mitigate and adapt to climate change impacts. Given these differences, the participation of every member of a community is crucial. With the awareness in necessity of this fact, the plans and policies in recent years that aims to develop climate resilient society accepts the inclusion of every component to a society via GESI components as Inter-thematic areas – that overarched all the sectors and activities. Gender equality and social inclusion (GESI) will be incorporated into the plans to mitigate and adapt to climate change as part of the 2019 climate change policy. The second NDC lays out GESI-responsive targets specific to different sectors as well as GESI as one of the main cross-cutting component. It has set a target to develop an Action Plan for integrating GESI in achieving NDC targets by 2030. According to the NDC, its execution would adhere to "equity principle to make sure it is equally accessible to youth, children, women and tribal and marginalized population for making decision, participation, and sharing- benefit from the implementation of NDC." In addition to that, the National Adaptation plan also recognizes GESI as essential components, designating specific targets and have budgeted about 0.7 million USD for GESI specific activities.

2.9 Climate resilient agriculture

Climate-resilient agriculture (CRA) approach is generated to tackle the agricultural uncertainties generated due to the climate variability which promotes the concept of utilizing local resources such as agricultural produces and animal husbandry systems for sustainable productivity and farm incomes. By predicting dangers, preparing for them, and then adapting to, absorbing, and recovering from the effects of climate change and harsh weather, climate resilience aids to manage climate risk.

Adaptive agricultural techniques that can survive the shocks of climate change and weather extremes are the focus of climate-resilient agriculture practices. These procedures must be adaptable enough to deal with both short-term weather shocks like storms, hail, and droughts as well as long-term climate change. Climate change frequently causes water shortages or surpluses, and unfavorable circumstances need finding solutions that benefit everyone.

3. THE TRIPLE-WIN APPROACH

The fact that agriculture itself is one of the main causes of the climate crisis is a crucial component of this equation. According to estimates, agricultural and development practices account for over 30% of GHE, due to the use of chemical fertilizers, pesticides, and animal manure. Therefore, agricultural expansion both causes and exacerbates this persistent issue.

So, managing the aspects of agriculture and food security that are interrelated and directly impacted by climate change requires a multifaceted strategy. The following three objectives are targeted and achieved by climate-resilient agriculture, according to the World Bank, as a "triple win" strategy:

- Increasing productivity

Increase both quantity and quality for better nutrition and increased farmer revenue. This concentration is on the 75% of global population below poverty line who rely on agriculture and reside in rural regions.

- Resistance
- Improve the ability to flourish in the face of longer-term casualties for instance shortened seasons and changing weather patterns. Reduce sensitivity to water scarcity, pests, and other climate-related adverse occurrences.
- Sequestration of carbon

Reduce the amount of emissions produced while producing food, prevent deforestation, and support strategies for capturing and removing carbon dioxide from the environment (Asare, 2024).

To deal with climate change and make agri-production adaptable to shocks and changes in the environment, agriculture and development practices must adopt a planned strategy to adaptation.

3.1 Practices for Climate-Resilient Agriculture

Some procedures used by CRA include:

- Soil Resilience

Boost soil health, a crucial factor in increasing agricultural resistance to climate change. Increasing the soil's ability to retain water and build soil carbon are crucial elements that helpAdaptation in crop varieties (Asare et., al 2023a):

- To attain consistency in yields and improved productivity, introduce seed types that are resistant to heat, drought, and flooding. Depending on weather predictions and preparation, this must be done in coordination with the local farming community.

- Management of Water:

By collecting rainfall, reusing it, and reducing the amount of polluted groundwater, you may increase water reservoirs and replenish water tables.

- Conservation tillage

Utilize conservation tillage techniques to loosen the soil very little through physical means.

- Hiring farm equipment

To expedite plantation/sowing, provide rental facilities for farm equipment and contemporary technology. Affordable equipment availability aids farmers in coping with unfavorable situations like unpredictable rainfall patterns.

- Tolerance of livestock systems:

To improve tolerance to heat stress, build water reservoirs and buy heat-tolerant kinds of cattle. Key interventions include increased fodder production and availability through utilization of communal lands.

3.2 Practices for Climate-Resilient Agriculture with Relevance to Nepal

To achieve resilience, techniques for both short- and long-term climate adaptation and mitigation should be applied. In Nepal, some climatic extremes including wildfires, extremely high temperatures, an early monsoon, and drought are frequent, but they may be avoided by adopting common practices that are climate resilient. The spread and effects of forest fires can be significantly reduced by wind barriers and fire breakers such as rock walls, high wetness, and low resin plants. Pre-weather notifications and ideal crop calendars might also be useful based on past climate data and seasonal projections. The spread and damage of forest fires can be significantly reduced by wind barriers and fire breakers, such as rock walls, high moisture content, and low resin content vegetation. Likewise, depending upon the historical climate data and seasonal forecasts, optimal crop calendars and pre-weather alerts can assist the farmers in taking decisions beforehand to help them avoid heat stress, untimely arrival of rainfall and other climate variabilities to generate increasing crop yield.

Climatic abnormalities like drought, flooding, soil erosion, can be tackled by adopting the practice of agroforestry. Agroforestry stabilizes the soil by increasing soil organic matter, nitrogen availability, and microbial activity—all of which eventually reduce erosion—and sequesters the carbon that would otherwise be released into the atmosphere by the agricultural sector. Farmers can be co- benefitted by production of medical herbs, woods, timber and animal fodder. Drought tolerant crops (e.g. sesame, millet, sorghum, buckwheat) or local resistant variety of crops which can withstand the climate abnormalities should be promoted from ground level. Similarly, mulching the soil with locally available materials like hay, dry leaves, cover crops etc. can help to conserve the soil moisture and also stabilizes the soil structure giving long term benefits. It can also prevent land degradation and prevent greenhouse gas emission. Drip irrigation technology can boost the water use efficiency and reduce the weed infestation and soil erosion. In the hills of Nepal, terracing the lands has greatly decreased the erosion of soil by improving infiltration and reducing run-off. It has also improved the deposition of nutrients. increases macronutrient deposition and infiltration by reducing surface runoff.

Excessive rainfall during monsoon is the main cause of flooding and landslide in terai and mid-hills of Nepal which has caused great crop loss. To mitigate these calamities, practices like growing crops in raised bed, and managing proper drainage in the field can be practiced whereas, plantation of grass strips and cover crops can greatly reduce the raindrop impact in the barren soil, improve soil water infiltration, and therefore decrease soil erosion, flooding and landslide.

Outbreak of new disease and pest due to climatic factor is a happening issue. Integrated Pest Management (IPM) can be a viable solution to these issues. Initial measures like biological control using natural enemies, crop rotation, bio pesticides, pheromone traps can be used to under IPM.

Table 1: Major Climate change hazards, CRA practices and adaptation benefits

Hazards	Practices	Adaptation benefits
Wild fire	Wind breaks and fire breaks	limit the spread and impact of forest fires
Drought	Agroforestry, mulching, drip irrigation, Optimizing crop calendars, planting drought tolerant and local resistant varieties	Boost the water use efficiency and reduce the weed growth and soil erosion. Improves food productivity in the dry season.
Disease and pest	Integrated Pest management (IPM), biological control using natural enemies, crop rotation, bio pesticides, pheromone traps, resistant local varieties of crop	Sustainably tackle the pest and disease outbreak.
Soil erosion and land degradation	Mulching, Agroforestry, Terracing	Decreases surface runoff, which enhances macronutrient deposition and penetration while decreasing soil erosion (Asare et al., 2023b).
Flood, Landslide	Mulching, planting cover crops, terracing, raised bed system	Reduce the raindrop impact in the barren soil, improve soil water infiltration

4. Conclusion

Albeit there are plenty of evidences showing smallholder farmers' vulnerability to the threats possessed by the changing climate, the efforts for adaptation and mitigation of the threats are seriously impared due to lack of proper strategies and the awareness on the magnitude of impact of climate change on agricultural productivity. It is past time to value and strictly execute the principles of climate-resilient agriculture (CRA), to improve the agricultural revenue. It is clear from this review that agriculture is one of the industries that is directly or indirectly affected by the irregularities brought on by climate change. Since 60.4% of Nepal's population depends on agriculture as their major income source, this has a big impact on the farming community's economy and way of life. Although some efforts have been taken by the local government bodies to engrave climate change policies in the developmental planning, there is still lacking in the detailed study of the impact of climate change in agriculture and development of policies to build climate resilient agriculture system along with its implementation.

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