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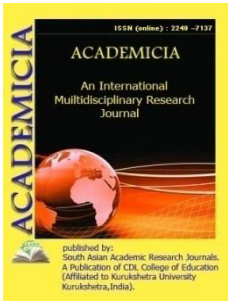

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THE IMPACT OF CLIMATE CHANGE ON NEPALESE AGRICULTURE

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ABSTRACT

Climate change is caused by the exponential increase of CO_2 and other greenhouse gases in the atmosphere. Agriculture, biodiversity, forestry, people's health, snow cover, and aquatic and mountainous ecosystems all suffer as a result. Climate changes such as temperature, solar radiation, or precipitation have the ability to affect agricultural output. Despite many attempts to mitigate the effects of climate change, Nepalese agriculture continues to face challenges. The nation saw a 1.8° C increase in temperature from 1975 to 2006, with an average of 0.06^o C/yea. Climate change has caused Nepal to suffer regular droughts, catastrophic floods, landslides, and a variety of impacts on agricultural products. According to a study conducted at Khumaltar on CO_2 enrichment technology, rice and wheat yields rose by 26.6 percent and 18.4 percent, respectively, owing to double CO_2, 17.1 percent and 8.6 percent due to temperature rise. A crop simulation model used to investigate the impacts of CO_2, temperature, and rain on rice and wheat yields in NARC found a favourable effect in all areas, but a negative effect in maize, particularly in Terai. In Nepalese agriculture, the time has come for authorities to devise adaptive strategies to minimize the impacts of recent unpredictable weather patterns in order to prevent incalculable natural catastrophes and sufferings.

KEYWORDS: *Agriculture, Climate, Greenhouse, Yield.*

1. INTRODUCTION

Climate change is occurring. Climate change is a phenomenon brought on by greenhouse gas emissions from fuel combustion, deforestation, industrialization and urbanization, which results in changes in solar energy, temperature, and precipitation. It poses a serious threat to people's lives all over the world, affecting water resources, agricultural production, coastal areas, fresh water, vegetation, including forests, snow cover and melting, geological processes such as landslides, desertification, and flooding, as well as food security and human health in the long run[1].

Instead of agriculture, greenhouse gas emissions are the focus. Water vapor, nitrous oxide (N_2O), carbon dioxide, methane (CH_4), and chlorofluorocarbons are the primary gases that contributes to greenhouse. The three major greenhouse gases, CO_2, CH_4, or N_2O, are responsible for about 88 percent of global warming. Harrison and Aiyer identified the potential of CH_4 emissions from rice fields as early as 1913.The concentration of CH_4 gas in the atmosphere is currently increasing at a rate of 3% each year. By 2100, methane levels are projected to rise by 3.0 to 4.0 ppm, potentially causing significant climate change. According to a research performed at the Nepal Agricultural Research Council in Khumaltar, the average seasonal methane emission from rice fields under rain-fed circumstances was 28 kg/ha/season. In rice fields with 50 percent nitrogen and 15 cm stubble, the maximum average methane gas was 49.03 kg/ha. A minimum of 7.7 kg/ha of methane gas was found in the control fields. More research on GHGs in different eco-zones is required to more precisely quantify and verify their effect on agriculture[2].

Thailand or India, respectively, released 49 and 45 kg/ha of methane. Nepal has fewer emissions than developed countries due to a lack of irrigation infrastructure as well as fertilizer usage. The greatest methane emission from rice was measured at 367 kg in Korea. It may be because of increasing chemical fertilizer usage and better irrigation system.

1.1.Agriculture, as well as the weather, are both important factors.

Weather is an atmospheric condition that has an impact on agriculture on a surface timescale of minutes to weeks. During the monsoon season, which lasts from June to September, Nepal receives more than 80% of its annual precipitation. The effects of increasing temperatures and unpredictably wet weather on crops have a direct influence on agriculture and food production. The quantity of rain that the monsoon brings has an effect on production. Agriculture is susceptible to short-term weather changes, which have an impact on crop yield. Droughts are caused by a lack of rain and increasing temperatures, while heavy rain in a short period of time reduces ground water recharge by accelerating runoff and causing floods. Both of these factors have a negative effect on agriculture. Regular weather patterns are also disrupted by climate change, causing monsoon intensity and duration to fluctuate[3].

1.2.The impact on Nepal's agriculture industry Nepal's economy is based on agriculture:

Increasing temperatures and CO_2 emissions help important crops grow to some extent. Improved photosynthetic processes, water use efficiency, physiologic period shortening, or soil microbial activity, for example, may result in increased agricultural production. Negative effects include increased respiration, fertilizer use efficiency, shift in agricultural zone, increase in insect pest

population, desertification, increased soil erosion, evapo-transpiration, and malnutrition in a world overflowing with food due to reduced protein and mineral nutrients content in various crops. A decrease in fertile land in some places and an increase in others has an effect on agriculture. As a consequence, the world is confronted with a tough problem. Increased CO2 aids plant development, and yields will improve by 40% if CO2 levels are doubled. With rising CO2 concentrations, Annex 1 reveals some promising outcomes[4].

1.3.Climate Change Evidence in Nepal and Nepalese Agriculture:

1.3.1. General:

- The twelve hottest years between 1975 and 2007 (e.g. 2006 was the warmest year)
- Excessive runoff and poor groundwater recharge were caused by late or pre-monsoon precipitation, atypical precipitation, fewer wet days, and strong rainfall events.
- In the terai areas, extreme fog conditions have lately been recorded.
- In Kathmandu, the traditional rainfalls of Jestha and Ashar (mid-July) have been moved to Shrawan and Bhadra. It has had a detrimental impact on paddy output.
- Due to a rise in air temperature in the alpine environment, precipitation is decreasing and glaciers are receding (AX010 tiny glacier mountain is disappearing at an alarming pace).
- The number of frost days in the KTM valley is reducing, winter has arrived a month later than usual, and snow has fallen in Kathmandu.
- An unexpected snowfall in the Darchula region of the nation recently hampered the gathering of valuable medicinal plants Yarsagumba.
- Mosquitoes from the Terai and the Mid-Hill may live in the highlands.

1.3.2. Agriculture:

Early monsoon caused a rain shortfall in the Eastern Terai in 2005/06, reducing agricultural output by 12.5 percent on a national scale. Due to a lack of rain, almost 10% of agricultural land was left fallow, although the midwestern Terai saw severe rain and floods, reducing output by 30% in the year. Early crop maturation as a result of rising temperatures may allow for more crops in the same agricultural cycle (NARC annual report). There has been a shift in climatic zones throughout the nation. Natural vegetation extinction was also documented, including native basmati rice types, some local wheat, maize, and other agricultural crops. • The cold wave in Nepal in 1997/98 had a significant effect on agricultural output, with decreases in potato, toria, sarson, rayo, lentil, and chickpea production of 27.8, 36.5, 11.2, 30, 37.6, and 38 percent, respectively[5].

1.3.3. Objectives:

- To familiarize students with the idea of climate change and its implications for agriculture.
- Assisting policymakers in developing solutions for dealing with climate change and its effects

1.4.Climate Change's Impact On Agricultural Lands nd Agro-Ecozones:

Plains, hills, mid hills, high hills, and mountains are some of Nepal's agricultural zones. Changes in agri-zones result in changes in the zone's cropping pattern. Climatic variables have the ability to alter the distribution of agricultural crops ecologically. The loss of biodiversity might be catastrophic if climatic zones shifted quickly as a result of climate change. Cold-water fish, plants, pasturelands, tree lines (apple trees), and cattle are all affected (Chauri). Temperature rises in the Terai area inflict greater harm to agricultural sectors, whereas in the hills and mountains, it is more beneficial for agriculture. Cropping patterns, as well as vector-borne diseases of humans and animals, are anticipated to change in higher eco zones as temperatures rise. Some lands that are currently unsuitable due to weather conditions may become desirable in the near future. Maize, chilli, tomato, and cucumber, for example, are now widely used in the country's Mustang region[6].

Fertility of the soil and water availability with more CO2 as a natural fertilizer, more food can be produced. Increased CO2 availability may decrease the minerals available in soil, resulting in more robust development of food crops. Increased warmth may decrease soil organic carbon, soil micronutrients, and accelerate decomposition by stimulating the soil's microbial community. The four largest rivers coming from the Himalayas. Crops, cattle, and horticulture are all heavily reliant on the available water resources in the nation. Changes in temperature and weather are a significant cause of changes in soil moisture availability. Increased evapo-transpiration owing to rising temperatures will need more water to alleviate drought. The physiological active phase and crop output are governed by water availability. Monthly temperature rises of +2o C and +4o C disrupted evapo-transpiration and evaporation, according to research. Reduced watertable, increased evapotranspiration, soil erosion, landslides, floods, flooding of standing crops, and reduced soil fertility are all possible vulnerabilities as air temperatures rise.

1.5.Climate Change Impacts on Major Crops and Livestock:

1.5.1. Rice:

Rice is the world's second most significant crop, with 525 million tons produced from 148 million hectors. It is grown at an elevation of 300-2300 meters above sea level. Rice output in South Asia must quadruple by the year 2020. Raised CO2 and temperature in the NARC at Khumaltar resulted in increases in rice production of 17.07 and 26.58 percent, respectively, even when the temperature in the chamber was increased by 6.2o C and 7.36o C. (Annex 2 and The greenhouse effect caused by doubling carbon dioxide was measured at 1.16o C, resulting in plots that were 9.51 percent higher than the ambient plots. The nitrogen content of rice grew by 16.3 percent as the temperature rose, but dropped by 9.8 percent when CO2 levels doubled. Due to the rise in temperature, panicle initiation, blooming, heading, milking stage, and crop maturity time have all reduced by 7,4,4,4, and 6 days, respectively[6].

1.5.2. Wheat

Wheat is the world's most significant crop, and Nepal's third. It covers 20% of the entire cereal land and accounts for 18.8% of the country's total cereal output. Wheat growth and production are heavily influenced by climatic factors such as rain and temperature. Even with a temperature rise of 6.94o C and a doubling of CO2, an experiment performed in an Open Top Chamber at Khumaltar showed an increase in wheat production of 8.63 and 9.74 percent (Annex 4 and 5).

The greenhouse effect caused by doubling CO2 was just 0.18o C and resulted in plots that were 9.74 percent higher than the ambient plots. Due to the rise in temperature, physiological development phases such as panicle initiation, heading, blooming, milking, and physiological maturity reduced by 14, 5, 9, 6 and 14 days, respectively. Increased CO2 levels in the C3 pathway in rice and wheat contributed to higher yields[7].

Under high CO2, wheat output rose by 41.5 percent in the Terai plain, 24.4 percent in the hill, and 21.2 percent in the mountain. The yield dropped by 1.8 percent in the Terai, but increased by 5.3 percent in the hill and 33.3 percent in the mountain when the temperature rose by 4 degrees Celsius under irrigated conditions. According to a research performed in India, there would be a modest reduction in potential yield of 1.5-5.8% in the subtropical zone, but a 17-18% decrease in the tropical zone. In a climate change scenario, it seems that rainfed wheat production would suffer more in Terai than in the mid-hill environment. At all degrees of temperature increase, the extra rains had a positive effect on wheat production.

1.5.3. Maize:

Maize is Nepal's second most important crop, although it is the main crop in the hills. The planting date of maize is determined by the availability of soil moisture during the pre-monsoon period. In the hills, relaying or mixed cropping are typical techniques to guarantee crop harvest. At mid-altitude, millet and soybean are extensively relayed, while peanuts and beans are also utilized as maize relay crops. Because it uses the C4 photosynthetic pathway, its grain production is less affected by rising CO2 levels in the atmosphere. In the terai, maize output rose by 9.0%, 4.9 percent in the hills, and 15.5 percent in the mountains. However, the yield fell by 26.4 percent in the terai, -9.3 percent in the hills, but climbed to 26.8% in the mountains as the temperature rose by 4 degrees. As a result, temperature response to maize crop is better in the highlands than in the terai and hills[8].

1.6.Crops for horticulture:

On 255 thousand hectares, fruits and vegetables are produced. In the current scenario, the impacts of climate change on horticulture crops are quickly becoming a concern. Tropical fruits (banana, mango, papaya) and other crops such as croton have been adopted in the mid hills, while off-season blooming has been recorded in high altitude crops such as peach, pear, and apple. The reaction of temperature and CO2 in tomatoes was studied using an open top chamber, which revealed that increasing CO2 boosted tomato output by 279 percent and fruit number by 205 percent when compared to field conditions. According to several studies performed in other countries, increasing CO2 in potatoes reduced the amount of components such as iron, zinc, manganese, and sulphur. The concentration of oleic acid in soybean seeds increased as the temperature rose, whereas the concentration of linolenic acid dropped (Thomas et al., 2003). In strawberries, for example, ascorbic acid and glutathione rose by 13 as well as 171 percent from ambient to ambient + 600 ppm CO2 conditions, respectively (Agriculture Research Service). When compared to plants cultivated in ambient air. The sourness of oranges rose by 75% when the CO2 concentration of the air was increased. Because of the rise in carbon dioxide gas, vitamin C (antioxidant) levels have increased by around 5%. (Kimball and Mitchell, 1981). The quantity of important vitamins in fruits and vegetables increases when CO2 levels rise in the environment, which helps to enhance human health[9].

1.7.Diseases and pests Parameters of climate change:

The growth and spread of pests and illnesses are influenced by temperature, rainfall patterns, and humidity. In the presence of a host plant, a rise in temperature or CO2 will result in an increase in pest population and disease severity. It accelerates the insect and pest reproductive cycle. As bug populations grow, there is a greater need for pesticides, which unwittingly harms both the environment and human civilization. Climate change will exacerbate the spread of pests and illnesses in tropical areas. Plain environment pests and diseases may eventually migrate to hills and mountains. Some diseases of key Terai crops (such as rust and foliar blight) have evolved in the hills and mid-hills, posing a threat to agricultural output[10].

1.8.Research On Nepalese Agriculture's Ability To Adapt To Changing Climate:

- Increased heat, drought, and insect resistance in crops.
- Increased irrigation efficiency via the use of drip and sprinkler irrigation.
- Water and nutrient management research in different agro-ecologies to address climate change.
- Green manuring crops including cover crops are being studied in order to maintain soil moisture, organic matter, and micronutrients.
- Models for climate prediction and its application are being researched.
- New technologies for a low-carbon economy are being researched.
- Land utilize planning, watersheds, vulnerability assessment, or resource management are all areas of research.
- Research into yield gap analysis to better understand the variables that cause climate change.

1.9.Improvements in Agricultural Productions Strategies:

- Encourage rural populations that rely on agriculture to attend seminars, workshops, training, and general education.
- Identifying current climate change problems affecting agricultural industries.
- Strengthen the Agricultural Research Station and commodities program in order to conduct effective climate change research.
- Interactive communication to farmers on climate change and its effects on agriculture in order to transfer technology.
- Preserving genetic resources to prevent biodiversity extinction.
- Crop insurance policies for social and food security.
- A shift in national policy in favour of farmer incentives, such as agricultural input subsidies and agricultural investment.

1.10. Recommendations:

The following key policy suggestions should be given top priority:

- Build irrigation infrastructure to mitigate drought risks.
- Develop minimal tillage and zero-tillage rice, wheat, and maize crops to minimize soil carbon and water loss.
- Develop heat- and drought-resistant kinds and breeds, as well as insect pest-resistant cultivars, and improve IPM mechanisms (integrated pest management).
- Develop safe agrochemicals to reduce agricultural pest and disease damage.
- To deal with weaknesses, develop collaboration and coordination among neighbouring countries.
- Create a climate-forecasting system to mitigate risks.

2. DISSCUSSION

The exponential rise of CO_2 and other greenhouse gases in the atmosphere causes climate change. As a consequence, forestry agriculture, biodiversity, human health, snow cover, including aquatic and mountainous ecosystems all suffer. Temperature, solar radiation, and precipitation all have the potential to influence agricultural production. Despite many efforts to minimize climate change's impacts, Nepalese agriculture continues to confront difficulties. Between 1975 and 2006, the country's temperature rose by 1.8 degrees Celsius, with an average annual rise of 0.06 degrees Celsius. Droughts, severe floods, landslides, and a range of effects on agricultural goods have all been induced by climate change in Nepal. Because climate change is real and happening now, there is a need to identify and adapt to its effects in order to deal with the agricultural sector's vulnerabilities. Nepal, as a developing nation, is becoming more susceptible as a result of climate change. However, other study results from other nations indicated that grain or food quality had deteriorated. Increases in temperature or CO_2 levels are also threatening to cause a hidden-hunger issue in humans by reducing the necessary nutritional content of food crops. The total effect of climate change on agricultural sectors is expected to be detrimental in the long term, according to the findings.

3. CONCLUTION

Climate change is real and underway, so there is a need of impact identification and adoption to cope with vulnerabilities in agricultural sector. Nepal being a least developed country, it is moving towards vulnerable situation due to climate change. As it is known, its effects cannot be completely controlled but effective planning and change in human habit towards a low carbon economy can slower down possible disasters. Enriched CO_2 has shown positive impact on yield of major crops in all geographical zones. However, some research findings from other countries showed reduction in grain and food quality. Increase in temperature and CO_2 levels is also threatening to bring hidden-hunger problem in human by lowering essential nutrients contents in food crops. It is concluded that overall impact of climate change in agricultural sectors will have negative impacts in the long run.

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