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Cultivating Change for the Nepalese: Analyzing the Impacts of the Climate Crisis on Farmers in Nepal

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ABSTRACT

The climate crisis is one of the most disastrous global phenomena, and developing countries are the most affected by it, even though they contribute to it the least. Nepal is one of the poorest countries in the world with an economy highly reliant on farming. However, rapid changes in the climate have negatively impacted their agriculture. Our research focuses on how the climate crisis affects farmers in Nepal, leading to poverty and food insecurity. The research paper includes six sections: the literature review, methodologies, case study, results, discussion, and conclusion. Through our research, we explore a link between climate change in agriculture, food insecurity, and poverty by analyzing the opinions of professors and farmers in Nepal. For the methods, we examine a case study on the Terai region, interviews, and a questionnaire. Our research aims to fill gaps in existing research by investigating the relationship between rural farmers and the government to execute solutions that help farming communities. Additionally, this paper addresses how the impacts of climate variability contribute to deep-rooted societal issues of poverty and food insecurity in Nepal. Ultimately, our paper illuminates the problem of the influence of the climate crisis on agriculture worldwide for future generations.

Introduction

"Of the 124 million people worldwide who face "crisis levels" of acute food insecurity, 76% were affected by climate shocks and extremes, according to the Food and Agriculture Organization, and more than half of the people in developing countries live in rural communities dependent on agriculture" (U.S. Global Leadership Coalition, 2021). Agriculture is one of the world's most vulnerable sectors to the worsening effects of climate change. In developing countries, agriculture is the primary source of livelihood and income for 50-90% of the population, with small farmers comprising 70-90% of that percentage (Institute for Agriculture and Trade Policy, 2001).

Nepal is the poorest country in South Asia whose working population is mainly made up of small-scale farmers (Economic growth and trade, 2022). These farmers significantly rely on agriculture for income as they contribute one-third of the country's GDP (FAO in Nepal, 2022). However, volatile changes in climate variability are reducing crop production, leading to poverty and food insecurity. Although farmers in developing countries may seem irrelevant to developed countries, their difficult situation is intrinsically connected to the global world, and one disruption may create ripple effects elsewhere. Thus, our paper aims to explore the greater impact of climate variability on poverty and food insecurity in Nepal through farmers.

Recent studies have shown that farmers in Nepal are experiencing detriments to the production of crops like corn, rice, and wheat due to climate variability (Karki, 2012, Gauchan, 2008). They have also analyzed the perceptions of rural farmers on climate change as well as data collection on multiple aspects. Furthermore, many sources indicate the need for new adaptations by farmers due to the adverse effects of climate change on crop yields. However, the situation lacks communication between farmers and the government.

Therefore, this paper aims to fill the research gap of making connections between the climate crisis, farmers, food insecurity, and poverty. By doing this, we hope to enhance the livelihoods of rural farmers by minimizing agricultural loss and increasing food security in Nepal.

This paper is divided into six sections, effectively reporting our findings to the public. The first section is the literature review looking at previous research on the impacts of climate change on agriculture globally and in Nepal along with government adaptation solutions. The second section details the methodology used in the research: interviews with professors and a questionnaire of rural farmers. The third section includes a case study of three specific impacts of climate variability on the Terai region of Nepal. We analyze this specific region because it is known as the "granary" of Nepal, producing 56% of national grain crops although it only makes up 23% of the total land area (Shrestha et. al, 2013). The Terai region's agricultural significance makes it vital in terms of Nepal's overall food production and food security, making it pertinent to our research question. Within the case study, we take an ethnographic approach to understand how the region is being affected by extreme climate variability such as floods, extreme temperatures, and drought. The fourth section displays the results of our findings from the two interviews and questionnaire along with comparing the opinions of the interviewees with the farmers. In the fifth section, we interpret the significance of our results and discuss the limitations of the study. We also hope that future researchers can continue investigating this topic due to the limited time allotted to complete our findings.

Literature Review

The literature review of this paper aims to examine key sources on the global impacts of climate change on agriculture, specific impacts within Nepal, and existing solutions. As a preface for the section, the main headings state very broad topics that are only briefly explored due to the time constraint and scale of the research paper.

Global Impacts of Climate Change on Agriculture

On a global level, agriculture in developing countries and rural areas often suffers the worst impacts from climate change. Farmers in these countries play a key role in agriculture as most of the agriculture is done by small-holder farmers. For example, a case study done in Nigeria shows that small-holder farmers had observed detriments due to climate change such as higher variability in rainfall and extreme weather events, affecting the growing season of crops. The study shows that many farmers do not have adequate resources to adapt to these changes because of a disparity in scientific understanding and rural awareness. This presents a need for improved education and government support (Ayanlade et. al, 2017). Similarly, in Central and South America, various crops such as coffee, beans, and maize, experience crop yield reduction due to extreme weather and drought causing potential effects on food security (Marengo et. al, 2014). Another study argues that South Asian countries are extremely vulnerable to greenhouse gasses which threaten economic vulnerability. The results of the study show that overall food production is shown to decrease by 2030, which will, in turn, raise food prices and lead to policymakers having to address food security in the future (Bandara et. al, 2014).

Impacts of Climate Change in Nepal

Nepal is a country that is very vulnerable to the effects of climate change but is highly dependent on agriculture for the livelihoods of people who mainly reside in rural areas. Climate change's impacts on agriculture worsen over time due to extreme temperatures, variability in precipitation, flooding, and drought. Rice, the primary crop produced in Nepal, is highly affected by extreme precipitation and temperature as seen in studies (Karki et. al, 2012, Rayamajhee et. al , 2020). For example, a "1% increase in extreme precipitation days results in a 5.34 kg loss in rice production per household" according to Economics of Disasters and Climate Change (Rayamajhee et. al , 2020). Additionally,

some studies state that higher-altitude areas are most affected by climate change as most of the sparsely dispersed population there consists of subsistence farmers (Karki et. al, 2012, Rayamajhee et. al , 2020). However, another study emphasizes the importance of the Terai region in terms of climate impacts on agriculture as it produces 72% of national rice and a large portion of other grain products like corn and wheat (Budhathoki et. al, 2019). In terms of climate change impacts, extreme heat, and cold have also been studied, with one source claiming that although both have negative health impacts on farmers, farmers are less adapted to cold spells (Budhathoki et. al, 2019). The monsoon season, ranging from June to August, is vital for agriculture in Nepal as it brings most of the country's annual rain. Studies argue that because Nepal's agriculture is so dependent on the increasingly variable monsoon season, social problems will occur as crop yields decrease (Karki et. al, 2012, Dewan, 2015). Floods are another significant impact of climate change on farmers which not only risk loss of life but also cause inundation of crops. This stems from increasing glacier melt in the Himalayas and more extreme monsoon rainfall which can be traced to climate change (Dewan, 2015). Common methodologies used throughout the studies include qualitative methods such as surveys and interviews, as well as quantitative methods such as statistical data analysis. Overall, extreme temperature variability leading to drought along with extreme rainfall leading to flooding are the major impacts of climate change on agriculture in Nepal.

Governmental Action and Adaptation

There have been many studies conducted on adaptation strategies for farmers and government policies dealing with negative impacts on agriculture due to climate change. For example, the Nepalese government has policies on climate change specifically regarding agriculture. One policy discusses developing flood and drought-resistant crops as well as improving indigenous education (Government of Nepal Ministry of Population and Environment, 2016). The Nepalese government also showcases adaptation strategies and building resilience within communities through methods like flood risk reduction, which connects to farmers as many rural communities depend on agriculture (Ministry of Population and Environment, 2016). Additionally, the Consultative Group on International Agricultural Research (CGIAR) published a working paper in 2013 with plans and policies directly and indirectly aimed at tackling climate change in Nepal, such as the National Adaptation Programme of Action (2010), which discusses adaptation measures in response to climate change through agriculture (Sova et. al, 2013). However, another article stated that many government policies addressing floods in Nepal often didn't take traditional knowledge into consideration, for example, the National Adaptation Programme of Action mentioned earlier (Dewan, 2015, Karki et. al, 2012). Another working paper from DIIS adds that Nepal is very susceptible to natural disasters, with "64 out of Nepal's 75 districts being prone to disaster", and high rates of migration out of the country occurring due to poor agricultural performance (Dhungana et. al, 2013). This paper also concludes that perceptions of climate risk differed between local people and officials, and political conflict and institutions contributed to weak climate action after analysis of past policies from Nepal. They have seen support for climate adaptation and mitigation policies, but believe there is still room for improvement in translating local concerns into policies. However, they believe National Government Organizations are likely to play a key role in terms of support in the future (Dhungana et. al, 2013). This could be shown through Nepal's National Adaptation Plan or NAP extending from 2023 to 2050 which was put into place in order to address Nepal's high risk of climate extremes, by integrating adaptation into most policies (UN Environment Programme, 2023).

Methodologies

The conducted research is designed to take information from handpicked research articles and answer questions from individuals associated with the topic in a qualitative manner. Utilizing a qualitative research method allows for different perspectives to be showcased, adding a more holistic and human lens to existing quantitative data available on the topic. The qualitative data from this paper summarizes the opinions of both experts and rural farmers, also providing

a framework and guide for future quantitative research. The main methods of data collection for the paper are in the form of interviews and a questionnaire.

For the interviews, through personal connections, we found and selected The International Centre for Integrated Mountain Development (ICIMOD), an intergovernmental organization working for the benefit of the Hindu Kush Himalaya region, as our main focus for the interview. Within their organization, we then searched for professors from Nepal who perfectly aligned with our research purpose, Dr. Bhupesh Adhikary and Dr. Surendra Raj Joshi. Dr. Bhupesh Adhikary, who specializes in air pollution and climate science, was contacted through email and agreed to conduct an online interview through Zoom. We used a structured interview format by preparing the questions on topics such as the impacts and solutions for rural farmers beforehand. Following the first interview, we decided to conduct a second interview with Dr. Surendra Raj Joshi, because of his specialization in adaptation solutions for rural mountain communities. A semi-structured interview format was used to interview him. In addition to the interview, we also sent out questionnaires to farmers living in the Terai region of Nepal. Through personal connections, we were able to seek out farmers working in the Terai region. Due to the language barrier, we found a translator who helped the farmers translate their answers from Nepali into English. In the end, we were able to gather two responses from the farmers. Using the answers to the questionnaire and interviews, we compared and contrasted the different responses to analyze the viewpoints from a professional perspective and a local rural perspective on the issue. As our research is based on qualitative data, we used systematic analysis and comparative analysis to evaluate the interviewee's responses. Systematic analysis helped to organize our findings from Dr. Adhikary, Dr. Joshi, and the farmers in the Terai region by finding themes and analyzing quotes that address our research question. We conducted a similar method on the questionnaire of farmers to help us understand the direct experiences of the farmers as well as their knowledge of the climate crisis. We used comparative analysis to reveal the similarities or differences between both sources and to gain knowledge based on their opinions to show any present bias. One possible ethical concern for our research on the Terai region of Nepal is the fact that we used an outside translator to translate responses for our questionnaire. This could mean that some information was lost or mistranslated. Additionally, as our connections to the farmers surveyed in the study were personal, this could mean that the data pool of farmers doesn't fully represent the opinions of all farmers in the Terai region.

Case Study

Background

Nepal is one of the most underdeveloped countries in the world. With a dense population and weak overall economy, the Nepalese mainly depend on agriculture as a source of income. Unlike other developed countries, the people of Nepal don't have the privilege and opportunity to spend their wealth as they are constantly fighting against the aspects of the climate crisis affecting their agriculture. Because of Nepal's high population density and rapidly growing population, farmers need to make sure they meet the needs of their communities. Failure to do so can result in food insecurity which is a leading cause of poverty throughout the country. Nepal is divided into three ecological regions based on increasing elevation: the Terai, Hill, and Mountain regions. The region this case study covers is the Terai region. This area is known for its fertile lands and subtropical climate which make it most suitable for agriculture. The area is also flat which makes it perfect for mass production of rice, wheat, and maize, through large farmlands. Furthermore, one-third of the people living in Nepal reside in the Terai region. The region holds about 11 million people who all largely depend on the crops they grow for sustenance. Additionally, 80% of the Nepalese are part of agriculture production, with two-fifths of the population living in poverty (Liu et. al, 2023). Climate change has been witnessed by the farmers in the Terai region and they have already started to take some action. However, as a result of poor government help, the farmers can only use their own knowledge to remedy the situation and their agricultural systems.

When farmers have more access to education and resources they can all help create strategies for the farmers to increase crop growth (Khanal et al., 2018).

Impacts

The Terai region in Nepal faces numerous extreme weather events such as floods, droughts, and heatwaves, which significantly impact the lives of farmers, leading to food insecurity and poverty. For instance, taking drought as an example, farmers rely on rainfall as a source of irrigation to grow crops, but in recent years more districts in the Terai region experienced severe droughts. According to the Department of Meteorology and Hydrology, since 2024, 11 of the last 17 winters from December to February have less than the minimum rainfall, and "seven winters experienced drought affecting agricultural activities" (Dhakal, 2024). These winter rainfalls are extremely essential for farmers as they are needed to nurture crops for them to germinate during the spring. However, there was only 7.5 millimeters of rainfall during the winter season of 2024, which is way below the average of 60.1 millimeters. This leads to the failure of crop production, which further exacerbates the lack of availability of food. For example, a farmer in the Terai region says, "It's the second year in a row that we are not able to grow wheat and other winter crops" (Dhakal, 2024). Since wheat is one of the most important cereal crops, its unavailability directly impacts food security. It in turn worsens the poverty among farmers who heavily rely on wheat for economic opportunities. Even drought-resistant crops cannot withstand intense drought, according to Nepal's National Adaptation Program of Action (Subedi, 2018). This again shows how severe the impact of climate change is on agriculture in the Terai region. Furthermore, droughts also cause a reduction of water availability in rural regions where farmers are mostly located. A study conducted by the International Water Management Institute says that access to water during the dry season leads to negative crop productivity (Nilhari Neupane et al., 2022). Without enough water, it increases crop stress, impacting food security and farmer incomes.

Similarly, floods are a major challenge for farmers in the Terai region. For instance, heavy rain in the southern Terai region in August 2017 triggered a widespread flood in 27 of 75 districts. This immense flooding affected more than 450,000 individuals, destroying 32,000 houses and all of the crops (Floods in southern Terai, 2017). The financial impact of this disaster was staggering, with an estimate of 56.7 million USD in losses of major crops in Terai region districts (Food Security Impact, 2017). Due to this damage to crops, the District Food Security Network (DFSN) categorized villages into different phases depending on the severity of food insecurity. It shows that "8 village development committees (VDCs) in Saptari were severely food insecure", which is in phase 4, and "256 VDCs were highly food insecure", which is Phase 3 (Food Security Impact, 2017). The DFSN also states that 778,000 people were in Phases 3 and 4, meaning that a significant portion of the population in the Terai region was experiencing acute food shortages, which highlights the vulnerability of the agricultural sector to extreme weather. This is because it creates cascading effects on local communities. Additionally, since this flood in 2017 was the most severe disaster in centuries, it created ripple effects such as soil erosion. This process washes away nutrients on the top layer of soil, which then causes landslides to occur due to how soft and unstable the soil is (Oregon State University Landslide Research Group: Landslide Information, 2024). Likewise, back in 2006, another flood hit the western part of Nepal. Because nearly half of the rural Nepalese farmers on the western side live below the poverty line, it is even harder for them to recover from devastating events. This flood exacerbated the already dire poverty situation, as many farmers lost more than 30% of agricultural production, worsening the poverty in Nepal (Nilhari Neupane et al., 2022).

In addition, another significant climate challenge faced by farmers in the Terai region is the occurrence of heat waves, which are dependent on monsoons. If there is too much rain during the monsoon season, it may lead to floods. On the other hand, if there is too little rain during the monsoon season, then it will lead to drought. Therefore, a suitable amount of rain is essential. Farmers depend on the monsoon season for crop adaptation and suitable temperatures for farming. However, as the climate changes rapidly, the timing of monsoons also is altered significantly. Without these seasonal monsoons, the temperature in the Terai region can easily peak over 45 degrees Celsius, leading to long periods of heat waves. (Why Focus on "Heat"? A Silent Disaster Unfolding in Nepal, 2023). For example, as

observed by the Department of Hydrology and Meteorology in 2024, 20 met stations in the Terai region have a temperature between 40 to 45 degrees Celsius; 17 districts between 35 to 40 degrees Celsius; and 19 districts between 30 to 35 degrees Celsius (*Terai Region Exceed 40 Degrees Celsius*, 2024). This demonstrates how unbearable temperatures are in this region, which results in the reduction of crop yields. It also increases evaporation rates, leading to water shortages for irrigation which is necessary for farming.

Moreover, heat waves are directly linked with poverty and food insecurity because they exacerbate the existing vulnerabilities among farming communities. When crop yields decrease, farmers also earn less, which pushes them into poverty. For instance, a farmer in the Terai region says, “Wheat crops are ripening prematurely this year due to rising temperature” (Ahuja, 2022). These premature wheat crops cannot fully develop, meaning that they are unable to be put on the market, indicating the reduction of farmers' incomes. Similarly, a report on the reduction of rice production shows that 0.48% which is 4183 kg of rice is reduced each season as an average of 1°C increases every summer (Rayamajhee et al., 2020). This data underscores the significant impact of rising temperatures on agricultural productivity and also ties in with food insecurity due to the decrease in food supply, meaning that fewer Nepalese in the Terai regions can afford food that is in limited supply due to crop reduction.

Results/Analysis

Nepal’s climate has changed significantly over time as the impacts of the climate crisis have made it much less suitable and predictable for farming. A graph published by the World Bank Climate Change Knowledge Portal showed that Nepal's annual average surface air temperature increased from 1901 to 2022 (World Bank Climate Change Knowledge Portal, 2020). For example, in 1970, the annual mean was 13.75 degrees Celsius, however, the temperature continued to rise as shown in 2000, increasing to a mean of 13.99 degrees Celsius. Finally, in 2022 it accumulated to a mean of 14.39 degrees Celsius. The difference in temperature between 1970 and 2022 was approximately 0.6 degrees Celsius, correlating with the overall global increase in temperature of 1.5 degrees Celsius. This demonstrates the overall impact of the climate crisis in Nepal because it matches with the fact that Nepal's environment would have been less susceptible to heat if it weren’t for the impacts of the climate crisis. We use this data point to show that Nepal’s other climate-induced natural disasters such as floods and drought have worsened over time due to the overall increase in temperature. This enhances the credibility of the responses by the professors and farmers as it aligns with the information they provide about the worsening climate impacts they have observed.

Interviews with Professors

These interviews were conducted with two professors, Dr. Bhupesh Adhikary and Dr. Surendra Raj Joshi from the International Center for Integrated Mountain Development, or ICIMOD, because their specialization perfectly aligns with our research purpose. Bhuphesh Adhikary holds a PhD and MSc in Chemical Engineering along with a dual bachelor’s degree in Economics and Chemical Engineering. Surendra Raj Joshi holds a PhD in Applied Sciences from the University of Natural Resources and Applied Life Sciences in Vienna, Austria. Through the interviews, we aim to gain insight into the perspective of climate change through the lens of professors with knowledge in similar fields. From Dr. Adhikary's interview, we hope to receive information on the connections between air pollution on crops. On the other hand from Dr. Joshi, we expect to learn more about the agricultural side, specifically integrated farming, adaptation solutions, and their impact on the climate crisis.

Dr. Adhikary

Dr. Adhikary studied economics as well as engineering and later discovered the effects of air pollution. Through the guidance of this professor and his own interest, he combined many interests such as simulations, chemical reactions, math, and meteorology, into one subject he now wanted to explore, air pollution transport.

A. "...say for example we're in monsoon season right now. Because we've had very heavy rainfall, you know, the roads are washed. So now we're hearing in the news that in the city like Kathmandu, because farmers cannot bring their food, the food prices have gone up, whereas in the villages, farmers can't take their produce to the city, so their produce is going to waste. … So even if it directly didn't impact your produce or agriculture, if it impacts your distribution systems, or if it impacts when you can sell and how you can sell and what price you can sell, it will have an impact on the farmers" (B. Adhikary, July 14, 2024).

This response from Dr. Adhikary shows the impact of climate change on farmers through natural disasters such as extreme rainfall. He mentioned that one way extreme rainfall impacts farmers is by inhibiting travel to the city to sell produce. This negatively impacts the livelihoods and business of rural farmers specifically those who may struggle compared to wealthier farmers with product distribution.

B. "...different people have different vulnerabilities to climate impacts. For example some people may need help when there's too much water or like some zones or some people may need help on extreme events. So early warning on climate disasters can save lives and property, and minimize property loss. … Second, I would also say awareness about climate, and to understand it" (B. Adhikary, July 14, 2024).

Dr. Adhikary's response in this quote shows two main points of the role of non-governmental and governmental organizations in fighting climate impacts on rural farmers: giving early warnings for climate-induced natural disasters, and spreading awareness about climate change. His response focuses on the governmental aspect of addressing climate change rather than focusing on the rural farmers themselves, which may demonstrate a disparity in understanding of rural communities by different people in higher-up positions.

C. "We are facing what's called a triple planetary crisis. You know, [Nepal has] mountains and forests and grasslands and fertile lands ... So we are a hotspot for biodiversity, and because that area has a lot of population, a lot of people living, we're developing very quickly, also facing a lot of pollution problems, water pollution, air pollution, plastic pollution, land pollution, solid waste. So we have a crisis of all of these" (B. Adhikary, July 14, 2024).

This quote demonstrates how Nepal is facing the triple planetary crisis, which is the already existing climate change, pollution, and biodiversity loss. The existing climate change will continue to worsen due to the effects of pollution, and this multitude of pollution will directly link to biodiversity loss in the mountains, as these pollutants not only degrade the natural environment, but also harm the daily activities of animals. This shows how the global crisis creates ripple effects, impacting the livelihoods in Nepal and disrupting the ecosystem of the region.

D. "And so we are vulnerable for several reasons. … There's migration, you know, … there is a lot of poverty, because this is a very poor part of the world. There's conflicts, several places have, and then there's a lot of the population who are not educated. And so you have poverty, three triple planetary crises, and then on top of that you have migration. So even if you were to explain the impacts of climate change and all. They're not educated to understand all these details …. There's no cell phone towers, there's no landline phones, there's no internet. How do you reach communities like that for a potential warning or a danger? " (B. Adhikary, July 14, 2024).

This quote from Dr. Adhikary illustrates the causes of vulnerability in rural communities. Some of the causes he mentions are migration, poverty, conflict, and lack of education. In particular, he mentions that a lack of education in rural areas hinders the ability of rural community members to understand climate change, which is also due to their remote locations and lack of resources, increasing vulnerability.

Dr. Joshi

On the other hand, after starting his career as a natural scientist, Dr. Joshi studied honeybees, agriculture, and applied sciences. In addition, he worked on diversifying and learning about the livelihoods of rural communities. He then

learned about the extreme weather conditions caused by the climate crisis and worked on ways to support his local communities.

A. "So, in a nutshell, the fluctuation in production, any fluctuation, you know, it can be five kg, it can be 100 kg, depending on the weather condition of the year. So which puts farmers at a big risk, because you cannot fulfill your commitments earlier" (S. Joshi, July 18, 2024).

Through this quote, Dr. Joshi expresses how fluctuation in the production of certain crops such as rice due to drought, for example, hurts farmers. As farmers aren't able to meet demands for selling their products, they may not be able to provide for themselves or their families, increasing the risk of food insecurity and poverty as well since agriculture is a big economic contributor.

B. "Much more can be done. Because if you go to mountain areas in Nepal, they always complain that we are not getting good support from the government. …[they should provide] access to technology and access to finance. The non government organization and the government organizations, they need to provide the access. " (S. Joshi, July 18, 2024).

This quote answers the question if the government is doing a good job supporting rural farmers or not. Dr. Joshi's opinion is that government support is currently lacking, and he has heard that rural farmers are not currently getting the support they need from the government. He also provides his opinion on what should be done to help rural farmers, which is providing access to more resources and support.

C. "...more than 60% of land [in Nepal] does not have an irrigation system. … Unlike in China, unlike in many other countries, we don't have a very good irrigation system. If rain is delayed. If it is, you know, not timely, then your agriculture is at higher risk. And because of the higher risk in the agriculture sector, agriculture is a main contributor to values for the rural mountain communities. So they start migrating. So first they migrate from rural, mountain areas to the suburban areas, from there to the urban areas, and from urban areas to out of the countries. Now we have, you know, one in five Nepali people out of the country, either in the Middle East or South Korea or the newest and other places…" (S. Joshi, July 18, 2024).

In this quote, Dr. Joshi explains an aspect of how climate change has cascading effects on the socio-economic condition of people in Nepal. He discussed the lack of an irrigation system in Nepal compared to surrounding countries which creates the risk of variable rainfall negatively affecting agriculture. Not only does this show that the methods in Nepal are unaccomplished, but that the government has not put enough care into the overall system of agriculture. This leading cause creates the migration of the Nepalese to more developed areas, which is a loss for the country as a whole.

D. "We, personally, initially started supporting rural communities with beekeeping and integrated farming. … So we support rural communities to grow cardamom, … you can use not only cardamom capsules or the seeds for the spice industry, but we also impart several communities to do the products with their weaving skills … And then you can also keep honey bees for the pollination of cardamom and also for the production of honey … So providing the forecast, providing the package of solutions for water management, for insect pest management, for improving the soil conditions" (S. Joshi, July 18, 2024).

Finally, Dr. Joshi talked about some of his own personal work done supporting rural mountain farmers in Nepal. He discussed farming cardamom and honey to support rural communities because cardamom can honey are two crops that can act as companions with a mutually beneficial growing relationship. He also talked about ways to adapt to climate risks such as providing forecasting technology, pest management, and water management resources, which help support the livelihoods of rural communities and prevent poverty.

Questionnaire with Two Farmers

For our research paper, we conducted a questionnaire among two farmers in the Terai region to further investigate our research topic, which is the impacts of the climate crisis on farmers. Our questionnaires are based on their experience with the effects of climate change, their personal stories, and their opinions on governmental support. Due to the language barrier between us and the Nepalese farmers, we searched for a translator who helped us interpret what the farmers had said, and then this translator carefully documented their responses to ensure accuracy and reliability in our data collection process. We were able to collect two farmers' responses (Farmer 1 and Farmer 2) to avoid bias and inaccurate information. From the two farmers, we expect to gain insight into how they are personally affected by climate change and what they believe are important solutions that should be implemented, because their voices act as a primary source of data that adds relevancy and credibility to our paper.

Both Farmer 1 and Farmer 2 cultivate multiple crops. For instance, Farmer 1 plants sugarcane, jute, tobacco, tea, cotton, cardamom, and fruits, whereas Farmer 2 plants wheat, rice, corn, barley, oats, soybeans, sunflower, canola, bananas, and mangoes. These plants are all economically beneficial to their incomes, contributing to their overall livelihoods and economic stability. However, the impacts of climate change are significantly affecting the productivity and sustainability of these crops.

For example, Farmer 1 provides personal stories and information regarding his experience with various impacts of the climate crisis. He mentions that, "In the Terai region, high temperatures lead to heat stress in crops like rice and wheat, reducing yields and increasing water demand. Low temperatures cause frost damage and delay crop growth, challenging farmers in selecting suitable varieties and managing irrigation." In this response, Farmer 1 clearly states how both heat waves and cold temperatures lead to damaged crop yields, presenting challenges in food management. Moreover, when we ask about flooding and how it affects farming, he shares that a few years ago his community experienced an unprecedented amount of heavy rainfall, submerging crops like rice and vegetables from flooding. This leads to devastating crop losses which hurt the incomes of farmers and require extra resources to recover from the damaged crops. He mentions, "This marks a stark reminder of how unpredictable weather patterns due to climate change can directly affect our farming and livelihood." Farmer 1 also mentions how, "In the summer of 2022, the temperature suddenly increased, causing maize plants to dry up and other plants to fall down, bringing many farmers financial hardships." Through these anecdotes, we can see direct evidence of how climate change has severe impacts on the livelihoods of farmers in Nepal through the loss and damage of crops such as rice and maize. This has greater economic and social implications due to the fact that crop losses for farmers have economic detriments for their communities and families, and potentially risk food insecurity for the entire region as well. Both of these circumstances lead to a cycle of poverty for rural farming communities in Nepal.

Similarly, we ask the same questions to Farmer 2 to receive responses from multiple farmers to add credibility to our paper. For example, Farmer 2 also mentions his personal experience on how heat waves, floods, and drought all, "stress crops, reduce yields, and increase water demand … extreme heat can also increase evaporation rates, leading to water shortages for irrigation … the lack of rainfall and inadequate irrigation led to significant financial losses" From this response, we can see Farmer 2 suggests a problem: three different crises caused by climate change, leading to irrigation system problems since there is no proper irrigation in the farmer's community. This also shows the need for there to be adaptations to help combat this problem and prevent crop loss as drought makes farmers reliant on irrigation. This irrigation problem can lead to deeper destruction of crops due to the lack of water needed for crops to germinate. Moreover, Farmer 2 shares a personal story on how drought leaves an impact on his crops. He says, "In 2023, the Terai region of Nepal faced a severe drought, and the dry conditions persisted throughout the growing season, causing crops like rice and wheat to wither and yield poorly." This emphasizes the fact that drought, which is also affected by climate change, has significant impacts on the productivity of crops and the livelihoods of farmers. With these damaged crops, farmers are no longer able to sell their crops, leading to increased poverty due to economic loss.

Furthermore, both responded with similar ideas for adaptation strategies. Farmer 1 explains some of the

strategies are, “crop diversification, which is planting a variety of crops with different climate tolerance; improving water management, which is implementing efficient irrigation systems; technology adoption; and soil heal improvements.” Similarly, farmer 2 says, “improving water management, crop diversification, soil health management, and policy support and infrastructure development to prevent loss of houses.” These are examples of adaptation strategies that can help mitigate climate change impacts and sustain farming productivity in the short term, but for long-term solutions, government organizations must also take action. Thus, we ask how the government can support rural communities.

They all mention that they hope the government can support them by improving rural infrastructure, investing in agricultural research and extension services to promote modern farming techniques, and water management to ensure reliable access to water for farming throughout the year. This again proves how farmers and the government need to work together in a coordinated effort to ensure food security and sustainable livelihoods due to the unpredictable weather patterns caused by the climate crisis.

The responses of the two farmers show that there is significant crop reduction due to floods, extreme temperatures, and drought in the Terai region. However, the personal story of the first farmer discusses the effects of flooding on his crops which created a financial burden. The personal story of the second farmer on the other hand discusses crop loss due to drought which also led to financial loss. A similar theme is that both of the farmers shared a large amount of information about adaptation strategies and traditional knowledge, in particular about irrigation systems to manage water scarcity during droughts. For example, the “kulo” was mentioned by both farmers, which is a traditional water management system that provides the distribution of water among farmers while reflecting the cultural knowledge of hydrology these communities possess. The experiences of the farmers truly resonated with us due to all of the sufferings they encountered that led to poverty and food insecurity.

Comparison Between Professor and Farmers

One of the big themes both the farmers and the professors experience and discuss is the hardship of flooding in the agricultural sector. For instance, the two farmers mentioned how flooding destroyed their crops, leading to production failure. Similarly, the two professors also mentioned that flooding can lead to the disruption of the irrigation system, which is essential to the growth of crops. Even though the four interviewees all experienced major setbacks due to flooding, their perspectives highlight distinct aspects of the issue. For instance, the two farmers shared a more vivid and direct account of the impacts of flooding, providing a more impactful story of the direct consequences that had a greater emotional response. On the other hand, the two professors discussed the crisis using a more informational and analytical approach, as they were the ones studying and learning about the crisis.

Discussion

The research shows that rural farmers and communities are experiencing increased socioeconomic effects such as poverty and food insecurity due to climate change. Key findings from the interviews include the climate vulnerability faced by rural farmers, increasing migration out of rural areas, and the desire for government support for farming communities. Some key findings from the questionnaire of farmers include local traditional knowledge of agriculture, a desire for increased government assistance, and accounts of climate change having direct impacts on crop production of farmers such as flooding, drought, and extreme temperature. Comparing the responses of the farmers to the responses of the professors, we can see that both express a desire for government action to be improved. These results demonstrate that there is a gap in communication and understanding between rural farming communities and the government of Nepal. Additionally, the results illustrate the severity and reality of extreme climate variability in Nepal right now, through personal accounts from farmers and knowledge from the professors. There is a lot of similarity when comparing the interview responses of the professors and questionnaire responses of the local farmers, which

means that both parties possess a shared understanding of climate impacts. However, there is a difference in the way the parties responded to and approached certain questions, which shows that the understanding of similar topics can be different between different groups. The responses from the Nepalese farmers show they are facing impacts on agriculture such as drought and flooding which reduce their crop production and negatively impact their livelihoods. When analyzing the responses from the professors, we can see that migration, poverty, food security, and economic stability are all interconnected with this problem. Looking at the two perspectives together proves our research question as the direct impacts on crop production of rural farmers connect to the technical information on broader social problems explained by the professors.

Comparing our results with the literature review, we can observe similarities between the impacts of climate change in Nepal with other developing countries around the world. For example, a study done in Nigeria showed that climate variability hurt crop production but farmers did not have adequate resources to adapt (Ayanlade et. al, 2017). Additionally, there were similarities in the types of climate impacts in Nepal such as floods contributing to crop reduction (Dewan, 2015). Finally, studies show that many governmental organizations often don't consider local knowledge in terms of adaptations and solutions (Dewan, 2015, Karki et. al, 2012), which was supported by our interviews and questionnaire responses. Through our findings in this research, we hope to pave the way for future researchers to expand on our work. Scientists and engineers can examine our results to find more methods of teaching about climate change to the Nepalese. In addition, by diving into the ideologies and flaws in the farmers' thinking, we can create new systems to implement in the farmlands of the Terai region to stabilize crop production. Through the interviews and the case studies from the perspectives of the Nepalese farmers, others can find ways to recommend governmental action in that area as most of the locals do not have the power to solve the hardships individually. We were not able to determine all of the information from our research because of various limitations. This task was given a time frame of four weeks and proved insufficient when working on our topic. In addition, we could not get all of the interviews with the professors we would have liked. With our answers gathered from the people we requested from, only two professors accepted the invitation to an interview. The number of farmers that could have completed the questionnaire would have also been more acceptable if a larger amount of responses were submitted. Furthermore, when gathering details from articles and other research papers, there were a limited number of data sets to pull from because not many articles have focused deeply on the relationship between Nepalese agriculture during the climate crisis and how it impacts overall poverty along with food insecurity. One suggestion to broaden our work for future researchers is to have fieldwork residing in Nepal. This method can offer an anthropological approach to our research topic and pull more information and perspective from native Nepalese Terai people. It can also strengthen our research by finding more people to interview who are connected to this issue. This can be professors from certain organizations or from communities who know about the climate crisis and its agricultural effects. In addition, we also hope to examine solutions to help these rural Nepalese farmers. These solutions include: crop diversification, planting varieties of crops with different climate tolerances, improving water management, soil health improvement, using methods like cover cropping and organic adjustments to enhance soil flexibility, technology adoption, exploiting climate forecasting and precision agriculture tools for timely decision-making, and accessing crop insurance and risk management tools for financial protection. These proposals are an idea of how we can improve the lifestyles of the farmers and populations in Nepal. This will support future research which should be done on this topic to see if they are plausible.

Conclusion

The research provided in this paper is based on how the impacts of climate change on farmers in Nepal contribute to rising poverty and food insecurity. From our interviews, we learned that social factors such as migration and food insecurity are caused by increasing carbon emissions, and about adaptation strategies. Additionally, the questionnaire from the farmers in the specific region provided similar insight on how the impacts of the climate crisis, which include floods, drought, and heatwaves, negatively impact Nepalese farmers and crop production. From both pieces of extracted information, we found that the climate crisis can increase food insecurity and lead to poverty in Nepal by

corroborating the many different pieces of our research. We began to dive deeper into the developing country of Nepal because of our connections in the area and because their economy is largely based on agriculture. Overall, the research revealed how the decrease in productivity within the farming economy can lead to poverty and food insecurity nationwide. We hope to inspire future generations to solve the poverty and food insecurity issue in Nepal. Starting in Nepal, we can then apply similar strategies to sustain other small, developing countries and help them better deal with the climate crisis in the future.

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