Impacts of Climate Change on Farmers and their Adaptive Strategies along the Essequibo Coast, Guyana

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Abstract- Climate change is impacting people and their environment at an ever-growing rate. Underdeveloped countries like Guyana, which are heavily dependent on agriculture for sustenance are most vulnerable to the effects of climate change compared to developed countries. Globally, climate change negatively impacts agriculture with serious implications for livelihoods. For this study, 114 semi-structured interviews were conducted in 18 villages on the Essequibo Coast, Guyana, where agriculture is the major economic activity. Climate data (temperature and rainfall) were obtained for the past three decades from the Hydrometerological Office, Guyana. We found that temperature has been increasing over the last three decades. Rainfall patterns were observed to be fluctuating with a general increase over time. A majority of the farmers experienced the effects of climate change but they were also unaware as to why these were occurring. Most farmers were affected by floods, which is becoming much more prevalent as a result of climate change. This resulted in major crop losses and had high financial impacts on farmers. Farmers have been using various methods to adapt to the changes. In the past, farmers used leaves and bushes to get rid of pests and diseases. Presently, farmers were using more chemicals and fertilizers. It is recommended that emphasis be placed on awareness to better equip farmers to cope with climate change challenges. This study complemented similar studies from different regions of Guyana and globally to offer resources to farmers and policy-makers on strategies for climate change impact and mitigation in farming.

Index Terms- Climate Change, Impacts, Farmers, Adaptation

I. INTRODUCTION

Climate change, the change in the expected weather in an area or region [6], has received increasing attention over the last few decades. Global average surface temperature recorded an increase of 0.6 ^{o}C in the 20th century [11]. The 1990s was recorded as the hottest decade in the last millennium [12]. Global temperature has increased by 0.3 ^{o}C to 0.6 ^{o}C since the last 19th century and by 0.2 ^{o}C- 9.3 ^{o}C in 1960-2000 [11]. Global temperature is expected to continue increasing by 1.4 ^{o}C to 5.8 ^{o}C by 2100, depending on the scale of fossil fuel burning [1]. These increases are attributed to an increase in anthropogenic activities.

Climate change is now recognized as one of the most challenging and complex problems facing the globe [20]. The progressive nature of climate change affects human societies and economies of many countries [23]. It results in wide spread effects on the environment and social and economic related sectors such as water resources, agriculture, human health, terrestrial ecosystems and biodiversity [5]. Changes in rainfall pattern are resulting in severe water shortage and flooding. The melting of the glacier can cause soil erosion and flooding [22].

Climate change is one of the major threats to food security globally. Agriculture is vital for food security since it produces food for the global population and is a primary source of livelihood for 30% of the world's workforce [7]. Agriculture, forestry and fisheries are the most sensitive sectors to climate, and hence production is expected to be affected by climate change [7]. Climate change can result in changes in growth pattern, increase in diseases and pest, increase carbon and decreases soil moisture, which put a strain on livelihood activities.

Climate change impacts on agriculture will affect food security in two ways. First, food production will decrease, resulting in lower supplies. Second, economic gains from agriculture will decrease, therefore impacting income and revenues. Low income countries have limited financial capacities to trade, and high dependence on their own food production may face difficulties in offsetting decline in local food supply [7]. Fluctuations in weather patterns can increase food prices, social and financial dilemma for the poor. Also,

producer groups that have limited abilities to cope with climate change; for example, rural communities risk their safety and welfare [7]. Globally, a 2 ºC rise in temperature would cost about 1% of the world's GDP [21].

The impact of climate change is greater in developing countries, that ironically have lower carbon emission compared to developed countries. Developing countries produce approximately 7% of global emissions versus 45% by developed countries and emerging countries 48% [19]. Poor economies, weak government and socioeconomic structures, and frail market access along with climatic phenomena (El Niño and La Niña) have grave consequences on developing countries [23]. Hence, adaptive strategies to withstand the impacts of climate change are crucial. Poverty stricken communities suffer tremendously as availability and access to human, social, natural and financial resources are limited. Most poor communities thrive on agricultural resources [23].

Guyana with a population of approximately 773,303 is bordered by the Atlantic Ocean to the north, Brazil to the south and southwest, Suriname to the east and Venezuela to the west. It is a small country sitting from 0.5 to 1 meter below sea level that has been experiencing the effects of climatic change over the past 50 years [3]. The bulk of the country's population lives along the coastline and the major economic activity is agriculture. Despite Guyana being ranked 148 in its CO_2 emissions [9], like most developing countries it is most vulnerable to climate change since it is characterized by high poverty rate, limited resources and its dependence on climate sensitive sectors as a major contributor to GDP. Due to its location, Guyana is particularly vulnerable to sea level changes and extreme weather-related activities, such as flooding [15]. There has been an increase in flood due to an increased in rainfall.

The impacts of climate change on Guyana have been increasing over the years. El Niña and La Niña conditions have been severely affecting Guyana. In 1998, the Government of Guyana declared a state of emergency due to the unprecedented drought conditions produced by El Niño conditions. Rainfall was below 50% normal in 1997 and 85% in March 1998. Damages were estimated by the Guyana Rice Board and Guyana Sugar Corporation to be approximately USD 30 million. The Government committed approximately USD 1 million to an emergency programme [23].

News reports in 2011 acknowledged the adverse effects of the La Niña conditions during the 2011 period. Progressive rainfall resulted in flooding in many coastal communities. In 2015, Guyana was affected by El Niño conditions which resulted in major losses in the agricultural sector. In May 2017, several Amerindian villages in Regions 7 and 8 were counting losses after a massive flood. The water was over 15 feet high and over 3000 residents were affected [13]. Homes were washed away and crops damaged. The Government through the Civil Defense Commission expended over GYD 7.9 million to provide relief to residents [13].

Since climate change is unpredictable, it is difficult to do preventative adaptation in Guyana. Adaptation by communities is largely local [23]. Community-based adaptation is instrumental in reducing vulnerability to climate change [20]. Reactive, rather than preventative, adaptations are occurring in Guyana as seen by the responses to El Niño and La Niña. Therefore, the community's response to climate change in Guyana depends significantly on its ability to cope with the challenges, and access to resources to minimize vulnerability [23]. Communities throughout time have been developing traditional ways to adjust to the impacts of climate change, and current generations have been building on this and developing various coping strategies for survival [23]. Families are finding additional sources of income, developing strategies to sustain agriculture such as man-made irrigation among others [23].

Adaptations vary from communities and regions across Guyana where some adaptive strategies may not be applicable to all communities. Although traditional adaptive strategies might not provide a solution to global change, they may be effective in community settings [23]. As knowledge of climate change increases and information gathered on the success or failure of adaptive strategies, more effective adaptive options will be available [18].

The Essequibo coast (Region 2) has been experiencing the effects of climate change over the years. Few studies have been done to understand how farmers are being impacted by climate change and how they are adapting. This study provides information on how farmers in Essequibo are being impacted and adapting to climate change. It complements studies conducted by researchers in other parts of Guyana. Guyana will, therefore, be provided with a collection of data that would be useful in crafting policies and legislations to combat and mitigate the effects of climate change. This information could be resourceful to the Office of Climate change in their quest to mitigate the effects of climate change across all sectors in Guyana and by extension the Government of Guyana when updating the National Climate Change policy that was drafted in early 2017. Hence, Guyana can benefit from climate change funds available to developing countries through the Green Climate Fund to implement adaptive strategies to mitigate the effects of Climate Change. This research aimed to document farmers understanding of climate change and past and present adaptive strategies used by them.

2. MATERIALS AND METHOD

2.1 Study Site

This study was conducted on the Essequibo Coast (7°4'60" N and 58°49'60" W in DMS (Degrees Minutes Seconds)), Region 2 (Pomeroon- Supenaam), also commonly referred to as the Cinderella County, Guyana (Figure 2). It borders the Atlantic Ocean to the north, Region 3 to the East, Region 7 to the South and Region 1 to the West. It stretches from Supenaam to Pomeroon with an area of

6195 Km^2. This region comprises low coastal plain, forested highlands and a small portion of hilly sand and clay region [16]. The backlands are forested, with logging being done on a small scale. Region 2 has a population of 46,810, most of which is concentrated in the coastal belt of the Region [16]. The major economic activity in this Region is agriculture, with rice farming being dominant [16].

2.2. Sampling

The sample size was determined using the representative sampling method. Representative samples are advantageous since it ensures all relevant types of people are included in the sample and the right mixtures of people are interviewed [2]. Non-probability or purposive sampling was used to achieve representative sampling. It is most widely used and controls are placed on the types of respondents chosen for the survey [2]. Farmers were the target of this research. From the six Neighbourhood Democratic Councils (NDC), three (3) villages each were selected, where there was active farming. The number of farmers from each village were extracted from the Guyana Elections Commission (GECOM) preliminary list of electors for Local Government Elections (2016). Twenty-five percent of farmers from each village were then randomly selected for the survey. Interviews were done with a total of 114 persons across 18 villages.

2.3 Data Collection

Individual surveys were done using simple random stratified sampling, so as to include all strata of people within the selected villages along the Essequibo coast [1]. Semi-Structured interviews were conducted. This is where the interviewer uses interview guides, which is a list of questions and topics that needs to be covered during the conversation in a particular order [4]. Climatic data (temperature and rainfall) were collected for the past 3 decades from the Hydrometeorological Department, Ministry of Agriculture, Guyana.

3. RESULTS

3.1. Climatic Trend

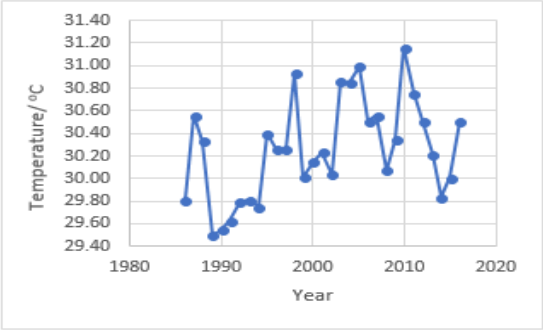

Figure 1: Temperature trend for the Essequibo Coast Essequibo Coast over the past 30 years

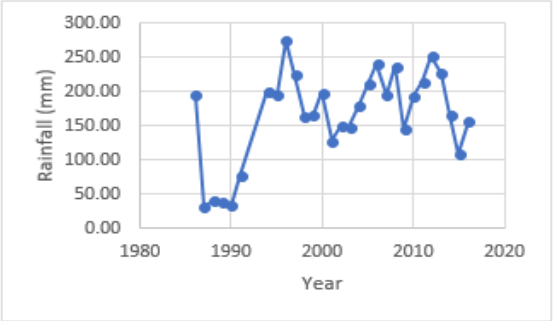

Figure 2: Rainfall pattern for the Essequibo over the past 30 years

Temperature is a major indicator of the occurrence of climate change. Although there were fluctuations (figure 1), there was a positive significant linear relationship between temperature and years (R2= 0.1842, p=0.015). The highest temperature was recorded in 2010 and lowest in 1989 (figure 1).

Rainfall is also a major determinant of climate change occurrence in an area. While there were fluctuations (figure 2), there was a positive linear relationship between rainfall and years (R2 0.228, p=0.008). The greatest amount of rainfall was recorded in 1996 and the lowest amount in 1987.

3.2 Farmers awareness of increasing changes

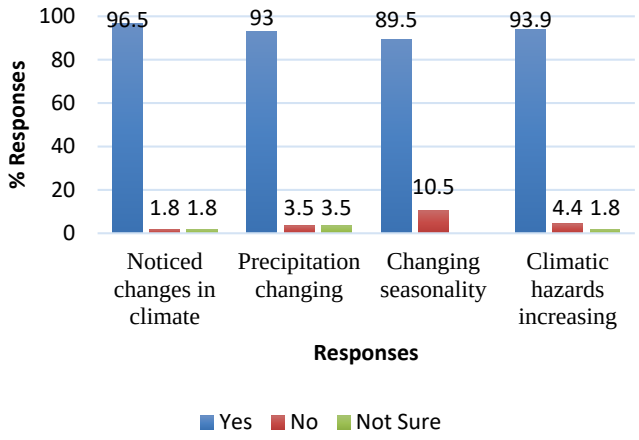

Figure 3: Farmers awareness of increasing changes in climate

A majority (96.5%) of the farmers observed changes in climate over the years, while 1.8% of them indicated that they did not notice any changes. 93% of the farmers indicated that rainfall patterns had been changing, while 89% observed changes in seasonality. 94% of the farmers were experiencing and increase in climatic hazards over the years.

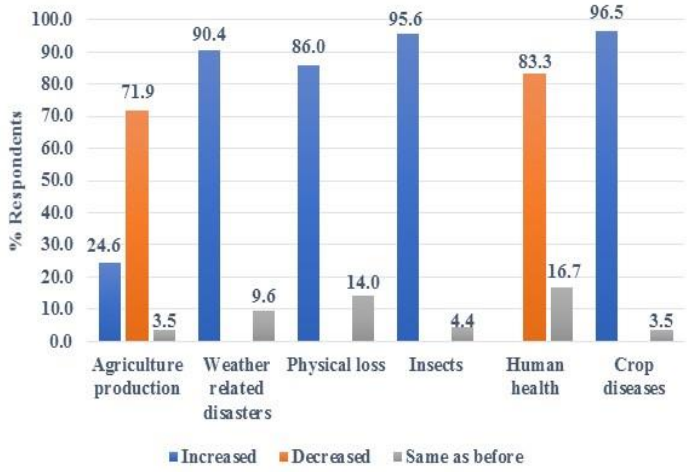

Figure 4: Effects of climate change in comparison to 20-25 years ago.

A majority of the farmers indicated that the effects of climate change had become more intense in comparison to 20-25 yeaes ago. Most farmers indicated that agriculture production (71.9%), as well as, human health (83.3%) decreased, while weather related disasters (90.4%), plysical loss of crops (86%), insects (95.6%) and crop diseases (96.5%) have trannscended normal levels. Few farmers (26.6%) indicated that agriculture production has increased. None of them believed that humans are becoming more healthy over the years.

4. DISCUSSION

4.1 Climatic trend

Temperature increases are a direct indication of climate change. There was an observed increase of 0.7°C in temperature on the Essequibo Coast over the last 30 years (1986-2016). The highest temperature in the past three decades was recorded in 2010. Rising temperature result in increased evaporation, leading to increased storms and a direct increase in rainfall [17]. There was an increase in rainfall on the Essequibo Coast over the past 30 years, with the highest being recorded in 1996 (274.38 mm). There was a decrease in rainfall fall in the 1980s and 1990s. It was perceived that drought conditions existed between 1986 and 1990.

4.2 Awareness of farmers to climate change

In Essequibo, while the majority of farmers heard of the term 'climate change' before, they did not know what it meant. Farmers were aware of the changes in climate but did not understand the reason behind them. There was a knowledge gap between climate change and the age of the farmers. This was statistically significant having a P value of 0.01963. The younger generation of farmers were more knowledgeable about climate change. The older generation had a better understanding of what the climate was in the past compared to current while the younger generation were more knowledgeable of the reason behind this change. Farmers with at least a secondary education were more aware of climate change. Some farmers believed that climate change is God's work and it was nothing to worry about.

4.3 Impacts of climate change

The agriculture sector's direct dependence on climate change and weather is what makes it so sensitive to climate change [14]. This impacts the livelihoods of the farmers. There were major decreases in production over the last two to three decades. Of all weather-related factors affecting agriculture, flooding was the most frequently reported by farmers. Guyana experienced major floods in 2005 and 2010, which were the highest experienced in the past three decades, resulting in millions of US dollars in damages. The average annual rainfall was recorded as 30.99mm and 31.16mm in 2005 and 2010 respectively. Storms and droughts were less common along the Essequibo coast. In 2017, the Essequibo Coast was hit with a freak storm that resulted in damages to several homes, disruption of electricity supplies and uprooting of trees [10]. Similarly, residents from Lima village on the Essequibo Coast in April 2018 experienced a storm, which caused damage to properties and injuries to persons [8].

The majority of the farmers suffered crop damages as a result of increasing weather-related disasters. Flooding, drought, and storms can destroy crops and also slow down the growth rate. Farmers indicated that their paddies were not germinating due to lack of water. Pest and diseases were also noted to be on the rise. Farmers reported that while they try to use chemicals to control the pest populations, they are growing resistant to the chemicals very fast. As a result, farmers would have noted major decreases in crop production compared to 20-25 years ago. They indicated that it is much more difficult now to plant their crops and the yield is less. Farmers would have suffered major financial losses.

4.4 Adaptation

Even though farmers' knowledge of climate change is limited, they have been experiencing the effects and are trying to adapt to these changes. Farmers in the past were facing some of the effects of climate change, but it was not as severe as what is being experienced presently. In the past, farmers utilized traditional knowledge to adapt to the changing climate. Most farmers applied chemicals that were available such as gramaxzone, 7 powder, agarose powders, and others. Farmers also applied their knowledge of plants such as neem leaves, black sage bush and grind pepper to combat some of the pests and diseases which affected their crops. They used soap powder and manually removed weeds. Farmers back then also planted different varieties of crops such as 6 months' rice. Currently, farmers are altering traditional cropping time. Farmers are trying to protect their crops from the changing patterns of rainfall, which will directly influence development and harvest. Some farmers have adapted crop rotation practices that helps in the reduction of some diseases and pest. Crop rotation eliminates the food source of pest so that their population can be controlled. Farmers are also applying chemicals and fertilizers to improve crop growth, pumping water and finding an alternative source of income. Few farmers were not attempting to adapt at all. This may be due to lack of finances or knowledge on how to do so.

4.5 Reducing the effects of climate change

Combating climate change is a major priority globally. The majority of farmers were unaware of how to reduce the effects of climate change. A few of them believe it is God's work and they cannot do anything. However, some believed that they can plant more trees, reduce deforestation, reduce burning and avoid pollution. Knowledge gaps existed; the farmers suggested that the government and other agencies should host more awareness campaigns. Farmers also recommended that financial aids can help them to cope with some of the losses they endure when their crops are destroyed. Improved infrastructure and officials getting more on the ground were some of the areas also highlighted by farmers.

II. CONCLUSION

Temperature and rainfall increased over the past decades in Guyana. There was a general lack of awareness/understanding of climate change among farmers. While they experienced changes in climate, they were unaware of the potential cause. Farmers were threatened mainly by floods that destroyed crops as well as their physical property. There was also a perceived increase in pest and diseases and an overall decrease in production. This led to major financial constraints. Farmers in the past used more traditional ways to adapt to a changing climate. Presently, farmers are engaging in crop rotation and changing the time of planting crops. Our results indicate that the need for education of farmers on climate change and helping them to adapt/ cope with the challenges faced by providing financial aid and other forms of support.

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