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Macro Analysis of Climate Change and Agricultural Production in Myanmar

Thida Htoo

Abstract

This study attempts to examine the effect of climate change on agricultural production in Myanmar. The study is based on country level data of Myanmar cereal crops for the time span of 2009 to 2019 obtained from various sources such as FAO STAT and Department of Agriculture and Department of Meteorology. This study is mainly used by multiple regression model to find out the best fit in the model. The research found that a 1°C increase in temperature in the growing period may decrease with production of cereal by 3849347 ton. A 1mm increase in rainfall in the growing period may decrease production of cereal by 5762 ton. The research found that change in temperature is adversely affected on production of cereal crops in Myanmar. The policies aiming to enhance production of cereal crops should focus on adoption of climate change adaptation measures in Myanmar.

Keywords: Temperature, Rainfall, Cereal crops, Adaptation measures, agricultural production

1. Introduction

Agriculture plays a vital role in the Myanmar economy and contributes around (20.9%) of the total GDP and is a source of employment for rural population of the country. The performance of agricultural sector has had large impact on the tendencies of Myanmar's GDP. About 70% of the rural population employs in agricultural sector. Myanmar is a leading and second biggest producer of rice and pulses. Myanmar agriculture not only contributes food grains but also contributes mainly towards the exports. Myanmar has the largest area of agri-ecological land in Southeast Asia and is the largest exporter for beans and pulses in Asia and ranks second after Canada in the world [1]. The improvement in agriculture sector becomes thus important for the betterment of growth of the economy.

The fluctuation of Agricultural production mainly depends on climate change. The climate change is closely associated with food security and poverty of majority of population in the country which mainly depend on agricultural sector [2]. The climate change largely affects Myanmar agriculture and become a challenge for future agriculture production in Myanmar [3] due to the reason that Myanmar is one of the top ten nations prone to climate change and extreme events like drought [4] in central dry zone of Myanmar, consisting of three regions namely the lower Sagaing, Mandalay and Magyay Regions, occupying 13 percent of total land areas

and 19 percent of total population of Myanmar [5]. The Central Dry Zone is a strategic area for the agriculture of the country as well as second leading rice producing region in which 22 percent of annual rice production provides for the requirement of the country. In the Central Dry Zone, Shwe Bo and Kyaut Se are the major rice producing areas where rice-based farming system is mainly adopted.

The Dry Zone is particularly at risk from floods and drought [6, 7] and has a serious water scarcity. As a result, Dry Zone becomes more vulnerable to the impact of climate change [8]. Coastal regions are also vulnerable to the impacts of rise in sea level and cyclones [6, 7]. Frequent extreme weather events have caused a decrease in productivity of agriculture and thereby leading to decrease in GDP and household income as well as a decrease in food security [9]. Agriculture and climate change are thus directly associated and have mutual effects. The climate change affects the agricultural production at both micro and macro scales [10].

This study attempts to examine the effect of climate change on agricultural production in Myanmar at macro scale. This study is divided into four parts: overview of Myanmar economy as part I, overview of climate change situation as part II, most common crops and production in Myanmar as part III, data source and empirical model as part IV and the effect of climate change on agricultural production in Myanmar as part V.

2. Overview of Myanmar economy

Myanmar's economic sector can be grouped into agricultural sector, industrial sector and service sector. Agriculture, livestock and fisheries, forestry sectors are considered as Agriculture sector; mining, processing and manufacturing, energy, electrical power and construction sectors are regarded as Industrial sector and finally transportation, communication, finance, social and administration, rents and services and trade sectors are grouped as Services sector.

Many efforts were being made by the government in attaining economic growth throughout the country. The government has been formulating and implementing national and regional level economic plans as well as sectoral development plans, aiming to accelerate growth, and to achieve equitable and balanced development all over the country through Framework for Economic and Social Reform (FESR) and Myanmar sustainable Development Plan (MSDP). Moreover, more investment on manufacturing sector were made by the government through providing technical assistance and loans to Small and Medium Enterprises (SMEs), and facilitating vocational training programs to labor force.

The economic growth was significant in 2010, reflecting the growth rate of GDP had been rapidly increasing till 2014–2015. The average growth rate of GDP had decreased to 9.5 percent due to the impact of Cyclone Komen in 2015. The economic growth had fluctuated and just above 5 percent since 2012, due to the reasons that the fluctuation in agricultural production associated with climate change and climate-related natural disasters and lack of capacity to adopt climate change adaptation strategies in response to climate change [11–13]. Over the same period, the share of the industry and service sector had increasing trend while the share of agricultural GDP had decreasing trend over the period between 2000 and 2019.

GDP of the country during the period between 2009 and 2010 and 2018–2019 can be seen in **Table 1**. During the period between 2009 and 2010 and 2014–2015, the economic growth rate was seen as upward trend, indicating an increase in growth rate due to government encouragement of manufacturing sector through providing technical assistance and loans to Small and Medium Enterprises (SMEs), and facilitating vocational training programs to labor force. Starting from 2015 to 2016, the

Year	Agriculture		Industry		Service		GDP (Kyats Million)	Growth rate of GDP
	Value (Kyat Million)	Percent	Value (Kyat Million)	Percent	Value (Kyat Million)	Percent	Value (Kyat Million)	Percent
2009–2010	15214305.5	30.2	19884328.3	39.5	15230298.2	30.3	50328932	5.7
2010–2011	15632203.6	30.3	20120658	39.0	15838569.3	30.7	51591431	5.9
2011–2012	16015275.5	29.1	22234265.6	40.2	16785769.9	30.5	55035311	6.7
2012–2013	16685355.3	27.9	24400089.5	40.8	18718696.1	31.3	59804141	8.7
2013–2014	17065701.6	26.1	26808190.3	41.0	21511938.1	32.9	65385830	9.3
2014–2015	18654719.7	25.3	30452170.9	41.3	24627179.4	33.4	73734070	12.8
2015–2016	19460590.9	24.1	33753224.1	41.8	27535524.9	34.1	80749340	9.5
2016–2017	20551566.4	23.2	37294006.3	42.1	30738765.3	34.7	88584338	9.7
2017–2018	20897983.7	22.1	40188430.1	42.5	33474598.2	35.4	94561012	6.7
2018–2019	21107523.6	20.9	43325969.4	42.9	36559442.8	36.2	100992936	6.8

Source: Ministry of Planning and Finance (2020).

Table 1.
Growth rate of gross domestic product and Sectoral contributions.

value of GDP had decreasing trend with 6.8 percent in 2018–2019 due to government encouragement on private sector in the service sectors as well as reduction in government budget on infrastructure for public sector projects. Though Myanmar economy still depends on agriculture sector, the share of agriculture in GDP is gradually decreasing with increasing share of industry and service in Gross Domestic Product.

3. Overview of climate change in Myanmar

Myanmar has a tropical climate with three seasons: summer, rainy and winter. Summer season starts from March and April, rainy season starts from May to October, and winter season starts from November to February. Seasonal temperatures vary largely in most of the regions/state in the country. The Central Dry Zone is highest in temperature and lowest in mean annual precipitation (500–1,000 mm/year). The maximum temperature has 40–43°C in the hot/dry season to minimum temperature has 10–15°C in the cool/relatively dry season and decrease from 0°C to –1°C in the hilly. The Coastal region, south of the country does not vary in seasonal temperature [14].

The climate trend over last six decades are found as a rise in mean temperature by around 0.08°C each decade; overall rise in rainfall throughout the country; rise in sea level and more extreme weather events such as drought and flood; and the monsoon period become shorter with more intense rainfall [15]. Over last three decade (1981–2010), temperature increased 0.14°C and 0.35°C per decade in coastal and inland regions. During the period between 1981 and 2010, total annual precipitation increased by 157 mm per decade in coastal areas and by 37 mm per decade inland [3].

Between year 2000 to 2010, the climate trend over last decades can be seen as large variation in highest temperature with 1.158°C and lowest temperature with 0.162°C. After year 2010, temperature had been an increasing trend from lowest temperature with 0.467°C to highest temperature with 1.552 [16].

Extreme weather events like droughts and flood are the main cause of natural disaster in Myanmar. The average annual rainfall of Myanmar is about 1630 mm, with half of the country lying within the 1500–2000 mm. Flooding and land slide occurred due to high intensity rainfall in dry zone areas [17].

The new climate change projections for Myanmar reveals a 0.8–2.7°C increase in minimum temperature and a 0.8–2.6°C increase in maximum temperature by the end of 2100 under representative concentration pathway (RCP) 4.5. Under RCP 8.5, minimum and maximum temperatures will increase by 0.9–4.6°C and 0.8–4.4°C respectively. Precipitation is projected to rise by 36 percent under RCP 4.5 and 40 percent under RCP 8.5.

Other key features of probable change at country level consists of increasing temperature with more extreme hot days and more extreme rainfall, resulting in more droughts and floods; increasing risk of flooding as a result of higher average rainfall intensity in monsoon events; more variable rainfall in the rainy season across the country (but particularly in the north) from March to November and a decrease between December and February [18]; more frequent and more intense extreme weather events, including cyclones/strong winds, flood/storm surge, intense rains, extreme high temperatures, drought and sea level rise [19].

4. Most common crops and production in Myanmar

Myanmar mainly produce the most common crops such as rice, pulses and beans, and maize and other crops in four different zones: Delta zone, Coastal zone,

Central dry zone, and hilly and mountainous zone. Rice is the main staple food crop, cultivating nearly 50% of Myanmar's agricultural land [15]. The Ayeyarwady Delta Region contributes the largest share of production of rice while central dry zone contributes the highest share of pulses and beans. Among the most common crops, rice is normally grown during the monsoon season and pulses and beans are largely grown during the dry season. The Delta zone including Yangon, Bago, Ayeyarwaddy, and Mon state largely grow major crops such as rice, and pulses; Coastal zone including Tanintharyi Region, Mon State, Kayin State mainly grow rice, rubber, oil palm and fruit tree; Central dry zone including Magway, Mandalay largely grow rice for subsistence, oil crops, pulses, sesame, groundnuts, vegetables and tea; hilly and mountainous zone including Shan, Chin typically grow rice, wheat, maize, sorghum, vegetables, sugarcane, and coffee.

The total arable land increased from 9909 hectare in 2000 to 11080.3 hectare in 2018. Major export crops are rice and pulses. The country has a huge potential for agricultural development due to abundant in natural resources but has been facing some constraints such as providing irrigation and provision of infrastructures, insecure land titles, limited financial resources, provision of farm inputs and extension services, limited use of farm machinery and low investment in the development of its agricultural sector. The annual variation of crop production and yields is caused by seasonal nature of farming, climatic variations and extreme events [17]. The precipitation, temperature and humidity influence the types, production and yield of crops depending on different spatial location, indicating that different climate in different location affect production of crop [20].

The crop yield has found significant annual variation over the past decade due to different factors such as holding with insufficient land appropriate for diversification covering with an average lot size of 2.27 ha [15] largely relying on rainwater for irrigation, frequent flooding and drought stress. The paddy production and yield had increasing trend over the past decade but decreasing trend after year 2010 due to the reason that paddy plantations were damaged in 2015 by flood, accounting for 79 percent of total damage areas and 89 percent of the destroyed crops [21]. More than a million acres of cultivated land were adversely affected by heavy monsoon-related flood in 2018 as well as about 250,000 acres were destroyed especially paddy, maize, sesame, various beans and pulses (Myanmar Time 2018). The production and yield had been increasing in 2017–2018 due to favorable weather and more provision of irrigated water to farmers [1, 16]. The 26.3 million tonnes of rice (paddy), 1.6 million tonnes of groundnut and 0.7 million tonnes of sesame seeds were produced under the crop land area of 110830.3 ha [16].

5. Data source and empirical model

This study is based on country level data of Myanmar cereal crops for the time span of 2009 to 2019 obtained from various sources such as FAO STAT and Department of Agriculture and Department of Meteorology. The data are classified into two parts: cereal crop production and meteorological variables (temperature and precipitation). The data on cereal crop production are obtained from FAO STAT and meteorological variables are obtained from Statistical Yearbook with various issues. The data on agricultural inputs such as use of pesticides, application of fertilizers was obtained from FAO STAT. Climate variables such as annual precipitation and maximum and minimum temperature have been taken into in the model. State and district-wise Annual rainfall data for the respective years (2009–2019) has been obtained from Central Statistical Yearbook from the Ministry of Planning, Finance and Industry in Myanmar [22].

6. Empirical model

The relationship between climate change and agricultural production for the years 2009–2019 is analyzed with an econometrics model using Panel Regression. The data were collected for the country as a whole. Cereal crop production in kg per hectare is taken into consideration as Dependent variable while climate variable (average annual maximum and minimum temperatures, and average annual precipitation), agricultural inputs (application of fertilizer consumption, and phosphate and potash) are regarded as Explanatory variables.

This study is mainly used by multiple regression model. This regression analysis has been conducted using “R” to find out the best fit in the model. The “R” was used to analyze the data collected, and results is presented in table. Linear regression inferential statistic was used to analyze the contributions of the independent variables to the dependent. The statistical modeling applies observed country data on production of cereal crops and historical weather records to fit Linear regression functions in order to predict the response of cereal crop production [23, 24]. As a statistical model, Linear regression equation is used to link variations in historical year-to-year cereal crop production to variation in particular climate variables.

The functional form of the equation may be written as [25].

$$(TProd) = f(TEMP, RAIN, FC, Phosphate, Potash) \quad (1)$$

Where, TProd stands for total production for cereal crops. TEMP, RAIN, FC, Phosphate, Potash denotes annual temperature, rainfall, total fertilizer consumption, phosphate and potash respectively. Climate factors, fertilizers, phosphate and potash are assumed to be input factors for growth of production of cereal crops in multiple regression model.

The above equation can be written in the multiple regression form as:

$$\ln(TProd) = \beta_0 + \beta_1 \ln(TEMP) + \beta_2 \ln(RAIN) + \beta_3 \ln(FC) + \beta_4 \ln(Phosphate) + \beta_5 \ln(Potash) + \mu_s \quad (2)$$

Where, β_0 is constant coefficient; β_1 , β_2 , β_3 , β_4 , and β_5 , are the coefficients for the respective variables and μ_s is the intercept term.

7. Effect of climate change on cereal production

Change in crop production are very sensitive to climate change particularly in changes in temperature and changes in rainfall [26, 27]. Climate change significantly affects the crop production due to the fact that crop production largely depends on temperature and water [28–30]. Climate change may lessen the period of crop maturation and increase in variation of crop yield, decrease suitable areas for crop production [31–33] decrease in crop yield, [34–36] and thereby leading to reduce crop production [37–39].

The result can be seen in **Table 2**. According to the result, the coefficient for temperature is found a negative and 1% significant in production of cereal crops in Myanmar. Temperature negatively affects the crop production due to the fact that temperatures in Dry Zone could reach 40–43°C during the hot dry season. This indicates that an increase in temperature reflects a decrease in cereal crop production in Myanmar. This means that a 1°C increase in temperature in the growing

	Estimates	Std. Error	T value	P(>t)
Intercept	144749537	37469082	3.863	0.00479*
Temperature	−3849347	1294063	−2.975	0.01775**
Rainfall	−5762	3095	−1.862	0.09966
fertilizer	−148386	122053	−1.216	0.25873
phosphate	−111175	449545	−0.247	0.81090
potash	63836	649849	0.098	0.92417
Multiple R-squared:				0.7575
Adjusted R-squared:				0.606
F-statistic:				4.999

*1% significant.
**5% significant.

Table 2.
Regression result of climate change on cereal production.

period may decrease with production of cereal by 3849347 tons. It is found that an increase in temperature strongly influences on crop production and the temperature-related extreme weather events have an association with the production of cereal crops. The result is the same with the finding of Lesk et al. 2016 that drought and extreme temperature adversely affected on production of agriculture across the world and also greater impact on production of cereal crops [40]; and finding of You L et al. 2009 who found that in term of cereal crops, the higher temperature can negatively effect on cereal production, reflecting a 1°C increase in temperature in the growing period may decrease production of wheat by about 3–10% [41]. The result is also consistent with the finding of [42, 43] in which higher temperatures may have negative impact on aggregate output. An increase in temperature-related extreme weather events have an association with reduction in production of crops in Myanmar. Due to the reason, irrigation is largely demanded in order to cope with reduction in cereal crops production. To cope with this condition, water storage need to be reinforced in order to capture rain to reduce water needs in growing season.

The result found that the coefficient for rainfall are also negative but not significant with production of cereal crop production. This indicates that an increase in rainfall reflects a decrease in cereal crop production due to the fact that heavy intense of rain may cause frequent floods in Central Dry Zone that greatly affect the production of crop. Mean annual rainfall is generally the lowest in the Central Dry Zone (500–1000 mm per year) that is prone to extreme heat events and drought. In term of cereal crops, the intense rain can negatively affect on production of cereal crops, reflecting a 1 mm increase in rainfall in the growing period may decrease production of cereal by 5762 tons. Changes in rainfall affects delaying planting date which keeps crops at risk under the condition of high temperature in the growing season [44].

The result also found that the coefficient for fertilizer and phosphate are negative but not significant with production of cereal crops, indicating that an increase in utilization of fertilizer and phosphate reflects a decrease in production of cereal crops. This means that improper use of fertilizer negatively affects the production of cereal crop production. One-kilogram increase in consumption of fertilizer per hectare decreases with 148386 tons of cereal crop production and One-kilogram increase in consumption of phosphate per hectare decreases with 111175 tons of

cereal production respectively. In order to improve production of cereal crop production, the social capital become urgently needed to incorporate and coordinate with respective stakeholders in order to adopt climate change adaptation measures such as stress tolerance crop varieties selection, enhancing drought resilience, drip irrigation technique for enhancing water use efficiency, sharing on climate resilient farming method among farmers, soil and water conservation, conservation and cultivation with local adaptable crop varieties in response to climate change. The same experience is found that the adoption of new technologies, such as drought-tolerant seeds, and changing farm practices, as sowing dates, are moderating the impacts of climate variability and change on crop yields [45–47].

8. Conclusion and policy implication

The research found that an increase in temperature and rainfall negatively affects the production of cereal crops in Myanmar due to an increase in temperature that causes water stress in growing season due to reduction in moisture of soil and consequently reduction in cereal crop production [48, 49] and an increase in rainfall negatively affects the cereal crop production due to intense rainfall.

As a micro level, the farmers can adapt the effect of reduction in crop production by crop diversification as a farm-level response and/or non-farm income sources. So that farmers can have benefits with optimal utilization of their marginal land, and reduction in extreme climate risks and events and improving resilience in smallholder farming systems [50–53]. In order to stabilize and increase farm income of the smallholder farmers, essential requirement is to encourage crop diversification by the government that generates raising farm incomes of smallholder farmers [54–56]. The relevant stakeholders need to provide knowledge and awareness for systematic utilization of farm inputs such as fertilizer and pesticide.

At the macro level, it is imperative for Myanmar to diversity its economy. Government needs to paid attention on integrated farming system that can generate employment opportunities and increase total income for farmers in order to response to climate change risk. Government need to pursue economic diversification strategies including expanding in climate sensitive sectors such as agriculture, fishery, forestry and energy and tourism that increase resilient in response to climate change. These sectors can provide employment opportunities and generate total incomes for long-term adaptation strategies. Government need to build capacity building program for all stakeholders including extension agents and farmers in order to be expertise in their farming operation thereby leading to manage reduction in crops caused by climate change.

Thus, policies aiming to enhance production of cereal crops should focus on adoption of climate change adaptation measures in Myanmar. Social networking between farmers and extension agents should be enhanced for natural resource management and adoption of climate change adaptation measures. On the other hand, policies targeting to increase cereal crop production should also proceed by scaling up programs. Government need to promote climate change adaptation measures such as drought resistant high yield varieties seeds; provide fertilizer and pesticide and skilled extension agents and services. Irrigation need to be sufficiently provided in order to improve the production of cereal crops. This indicates that water resource management become urgent need in Myanmar in order to capture rain and to reduce water scarcity in summer. Seasonal water shortage should be coped with water resource management and thereby leading to more efficient utilization of water resource [57] and improvement in crop production can be achieved. In sum, diversification become play a vital role for increasing resilience

within the sector for sustainable development and thereby providing country to employment opportunities and income which in turn leads to reduction in poverty in the long run.

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