Climatic Changes, Government Interventions, and Paddy Production: An Empirical Study of the Muda Irrigation Area in Malaysia

Ahmad Zubir Ibrahim

Senior Lecturer

School Of Government

College of Law, Government and International Studies

Universiti Utara Malaysia (UUM)

06010 UUM Sintok, Kedah, Malaysia

E-mail: azubir@uum.edu.my

Md. Mahmudul Alam*

Senior Lecturer

School of Economics, Finance & Banking (SEFB)

College of Business (COB)

Universiti Utara Malaysia (UUM)

06010 UUM Sintok, Kedah, Malaysia

Email: rony000@gmail.com

*** Corresponding author**

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Abstract

The Muda Irrigation Area is one of the main paddy production areas in Malaysia. Various efforts and approaches through government interventions have been implemented to ensure the continuity of paddy production in this area. However, there are different factors that have negative impacts on paddy production including climatic factors. Therefore, with the direct components of production such as land, labor, and technology, this study uses climatic factors and government intervention to examine the influence of these factors of production on the paddy production in this area. Based on the time series data from 1981 to 2010, this study conducted the multiple log linear Ordinary Least Square (OLS) regression by considering the Cobb-Douglas production function model. The major units of production, such as land, labour, and technology, have a statistically positive relationship with paddy production. Among the climatic variables, rainfall and the number of rainy days show a statistically significant and positive relationship but temperature shows a negative relationship with paddy production. The factors of external intervention such as government subsidies and market forces also show a statistically significant and positive relationship with paddy production. To ensure the improvement of paddy production as well as to minimize the effects of climatic change, government intervention should be continued in Malaysia.

Keywords: *Muda Irrigation Area; Climate Change; Paddy; Government Intervention; Cobb-Douglas Production Function; Technology; Malaysia*

Introduction

In Malaysia, paddy is a commodity that is under protection by the government and is categorized as one of the commodities in achieving the national self-sufficiency level. In 2014, the country issued 3,521 million tons of paddy where 2,645 million metric tons were produced and the rest were imported. However, to ensure the production of paddy at the self-sufficiency level (SSL), the government has invested considerably over the years. In addition, various forms of assistance or subsidies have been created to improve paddy production.

However, the production of paddy is related to natural factors such as rainfall and temperature that ensure the growth of crops in a good condition, which would provide a high yield. Recent climate uncertainty has an impact on the crop production. Events such as flood and drought not only reduce the production but it also results in the destruction of crops. Siwar et al. (2009) explained that climate change affects food production through geographic changes, unavailability of water for irrigation purposes, and the loss of land due to the rising sea level. Total yearly rainfall in Malaysia is increasing and its monthly variation is too high. The effect of lower rainfall can be controlled through a proper irrigation system, but the opposite phenomenon of over rainfall at any particular time, especially at the end of the crop cycle or at the maturity period that causes serious damage to crops, is completely uncontrollable (Alam et al., 2011a).

Under the current climate change scenario, temperatures of above 25°C may decline the grain mass by 4.4% per 1°C rise (Tashiro & Wardlaw, 1989), and grain yield may decline as much as 9.6%-10.0% per 1°C rise (Baker & Allen, 1993). On average, the temperature in paddy growing areas in Malaysia is about 26°C. Singh et al. (1996) mentioned that the actual farm yields of paddy in Malaysia vary from 3-5 tons per hectare, while the potential yield is 7.2 tons. It is also mentioned that there would be a decline of paddy yield between 4.6%-6.1% per 1°C temperature increase under the present CO₂ level, but a doubling of CO₂ concentration (from the present level of 340ppm to 680ppm) may offset the detrimental effect of a 4°C temperature increase on the paddy production in Malaysia. A study found that a 1% increase in temperature leads to 3.44% decrease in the current paddy yield and 0.03% decrease in paddy yield in the following season, and a 1% increase in rainfall leads to 0.12% decrease in the current paddy yield and 0.21% decrease of paddy yield in the following season (Alam et al., 2014).

The projections of rainfall and temperature based on the ongoing activities that strongly influence the climate factors in Malaysia reveal an alarming situation in the future. The projection also shows that by 2050, the maximum monthly precipitation will increase up to 51% over Pahang, Kelantan, and Terengganu, while minimum precipitation will decrease between 32% and 61% throughout Peninsular Malaysia. Consequently, annual rainfall will increase up to 10% in Kelantan, Terengganu, Pahang, and North West Coast, and decrease to 5% in Selangor and Johor (NAHRIM, 2006). Another projection shows that any changes, both positive and negative, of more than only 0.4% by 2020, will cause the yield of paddy

production in Malaysia to fall (Ramadasan et al., 2001). Due to high greenhouse gas emissions, the temperature is projected to rise by 0.3°C to 4.5°C in Malaysia. Warmer temperatures will cause a rise in the sea level by about 95cm over a hundred-year period. The changes in rainfall may fluctuate from about -30% to +30%. This change will reduce crop yield and many areas will be prone to drought thus cultivation of some crops such as rubber, oil palm, and cocoa will not be possible.

Further, Malaysian Meteorological Department (2009) simulated twelve coupled Atmosphere-Ocean General Circulation Models (AOGCMs), which show an increasing temperature trend for the three domains – Peninsular Malaysia, Sabah, and Sarawak (Table 1). The projected temperature increase among the nine AOGCMs for East Malaysia and Peninsular Malaysia are 1.0°C-3.5°C and 1.1°C-3.6°C, respectively. The ensemble rainfall is projected to increase most significantly in western Sarawak in comparison to other regions in Malaysia. Rainfall over the western Peninsular Malaysia is projected to increase while there is reduction in projection for eastern Peninsular Malaysia.

Table 1: Projections of Rainfall and Temperature Change in Malaysia

Region	Annual Mean Temperature Changes (°C)			Annual Rainfall Changes (%)		
	2020-2029	2050-2056	2090-2099	2020-2029	2050-2056	2090-2099
North West PM	1.3	1.9	3.1	-11.3	6.4	11.9
North East PM	1.1	1.7	2.9	-18.7	-6.0	4.1
Central PM	1.5	2.0	3.2	-10.2	2.3	14.1
Southern PM	1.4	1.9	3.2	-14.6	-0.2	15.2
East Sabah	1.0	1.7	2.8	-17.5	-12.8	-3.6
West Sabah	1.2	1.9	3.0	-8.9	-1.2	0.3
East Sarawak	1.4	2.0	3.8	-9.1	-1.3	6.2
West Sarawak	1.2	2.0	3.4	-8.8	3.8	14.6

Source: Malaysian Meteorological Department (2009)

Moreover, the climatic factors affect, directly or indirectly, the social and economic sustainability of the farmers. Climate changes cause crop damages, low productivity, and high production cost that lead to losses in farmers' income, increments in poverty levels, and increase in the seasonal unemployment rate (Alam et al. 2010b; 2011b). In Malaysia, the most vulnerable states in terms of poverty are Sabah (23%), Terengganu (15.4%), Kelantan (10.6%), Sarawak (7.5%), Kedah (7%), Perlis (6.3%), and Perak (4.9%), where the projected

temperature and rainfall changes are also very high (Ninth Malaysia Plan, 2006; NAHRIM, 2006). Therefore, in order to support the farmers and increase productivity as well as to increase the income of farmers, the government's intervention, especially through subsidy and incentives, are now essential in Malaysia. Abdullah et al. (2010) mentioned that the subsidy scheme has been able to increase the income of farmers, but in the absence of any subsidy schemes, the paddy production industry does not have high resistance and will not be viable. The Farmers Organization Authority (2008) also claims that the Fertilizer Subsidy Program works, as it provides encouragement and increases the interest of farmers to remain in the paddy production sector.

It is worth noting that the government of Malaysia currently provides huge amounts of subsidy to the paddy producers (Siwar et al., 2014). The government has allocated RM11,435 million for agricultural development in the 9MP (2006), which was increased by RM3,686 million (47.6%) from the 8MP. Until now, many policies have been introduced by the government to protect this sector such as price policy, subsidization policy, price stabilization policy, trade policy, etc. as summarized below.

Table 2: Government Subsidy for Paddy Sector in Malaysia

Incentives/subsidies	Description	Rate
Guaranteed Minimum Price (GMP)	GMP is important as a measure addressing the paddy and rice price in the country. GMP also works to guarantee the farmers receive reasonable rice sales. The rising price of rice in the market can be controlled with the proposed appointment of GMP.	1990 = RM 496.10/metric ton (paddy long) = RM 463.00/metric ton (rice medium) 1997 = RM 550.00/ metric ton 2006 = RM 650.00/metric ton (from Nov) 2008 = RM750.00/metric ton (from May)
Price Stabilization Policy (PSP)	Implemented since the 1980s, through the National Paddy and Rice Authority and managed by Padiberas Nasional Berhad (BERNAS) after 12 January 1996. Objectives to increase the income of farmers in PSP above the national poverty line and ensure that the price of rice in the market can be maintained at the level set by the Government for the interest of consumers. Government payments to the PSP is given to all farmers registered with the PSP Scheme, who sell rice from fields operated by themselves or by wages in the Rice Mills registered with BERNAS.	The early stages of the implementation of the subsidy price of RM33.20 were given to farmers for every metric ton of clean rice sold in the factory gate. 1982 = RM 167.00/metric ton 1990 = RM 248.10/metric ton (up to current)

Incentives/subsidies	Description	Rate
Rice fertilizer scheme of the federal government (RFS)	Implemented in 1979 through Farmers' Organization Authority. The purpose of (RFS) is to help farmers reduce production costs and promote the use of fertilizers as one input increases revenue production.	240 kg/ha: 12 beg x 20kg of compound fertilizer 100kg/ha: 5 beg x 20 kg of urea fertilizer
Increase in revenue incentives	The increase in revenue incentives was first introduced on 1 March 2007 aimed at encouraging farmers to increase rice production. This incentive is given to farmers who can increase revenue during at least one season per cent compared to the revenue base of the season.	RM650 /mt of yield for at least 1% increase from the base season
Paddy Seed Incentives	This incentive is intended to enable entrepreneurs to produce the rice seeds with valid returns accordingly. The program also aims to ensure that all farmers use seeds of paddy quality that are fully valid as a step towards improving the country's rice production.	RM 1.03/kg to paddy seeds producers who supply seeds to farmers.
Rice Production Incentives (RPI)	Introduced with effect from 1 March 2007. RPI was created to help farmers reduce production cost.	RM240.00/hectare/season - RM100/hectare/season (aid wages for ploughing) - RM140/hectare/season agricultural inputs (organic or foliar fertilizer)

Source: Malaysia (2008, 2010)

Therefore, with the direct components of production such as land, labor, and technology, this study aims at investigating the influences of climatic factors and government intervention on the paddy production in Malaysia based on a time series database on the Muda Irrigation Area.

Paddy Production in the Muda Irrigation Area

Basic adequacy of the local paddy through local production was the main policy of the government starting from 1955 until several years after the country had achieved independence. Change and the achievement of the target of this commodity at the SSL was translated into the five-year Malaysia Plan, National Agricultural Policy, Food Security Policy, New Economic Model, and the latest Agro-Food Policy. In order to achieve the objective, the government has developed eight paddy bowls in the country. One of the major paddy bowls is the Muda Irrigation Area (Figure 1). In 2010, the government allocated RM 41.383 million to the Muda Agricultural Development Authority (MADA) to conduct the

development and maintenance of the irrigation infrastructure in the Muda Irrigation Area (Malaysia, 2010a). To date, this irrigation area has contributed more than 40 percent of paddy production at the level of self-sufficiency of the country. The area is the largest direct contributor of paddy in the country ensuring food safety (Table 3).

Table 3: Paddy production in Muda irrigation area in Malaysia

Year	The country's paddy production (m. ton)	Paddy production in Muda irrigation area (m. ton)	Subsistence level commodity paddy (%)	The contribution of Muda irrigation area to SSL (%)
1985	1257970	724078	72	41.71
1990	1377339	724883	79	41.38
1995	1372584	862094	76	47.96
2000	1342370	760928	70	39.60
2005	1455440	880370	81	48.75
2010	1642000	909050	71	39.53

Source: MADA (2010)

Figure 1: Location of Muda Irrigation Area
Source: Ibrahim (2012)

Based on Table 3, the Muda Irrigation Area has contributed more than 40 percent of the country's paddy production, except for the years 2000 and 2010, when the yield was

around 39.60 percent and 39.53 percent, respectively. For a period of 40 years (1970 to 2010), the paddy production at the Muda Irrigation Area had contributed to the SSL of the country with an average of 45.6 percent. The percentage of this contribution defines the Muda Irrigation Area as the biggest contributor in ensuring food security in Malaysia. At the same time, the contribution of the Muda Irrigation Area also demonstrates that SSL investment and the government's efforts in ensuring the country's paddy supply in the Muda Irrigation Area has shown results of success despite having to deal with a variety of constraints such as natural disasters, diseases, and so on.

Natural disasters over the last few years have also affected paddy production patterns in the Muda Irrigation Area. A total of 48,693 hectares of fields have been affected by floods that have occurred from 2005 to 2010, resulting in a total of 32,794 paddy farmers being affected by this incident (MADA 2011). This has an impact on the production of paddy and SSL, and it affects the farm infrastructure in the area; it also affects the livelihood of the paddy farmers. Therefore, to achieve SSL in the paddy production in Muda Irrigation Area, extensive government interventions are conceded as very crucial factor (Johnson, 2000).

Methodology

With the direct components of production such as land, labor, and technology, this study used climatic factors and government intervention to examine the influence of the factors of production on paddy production in the Muda Irrigation Area. The time series data set from 1981 to 2010 was collected from MADA, the Meteorology Department, the Agriculture Department, the Ministry of Agriculture, and the Agro-Based Industry.

To draw inference, this study conducted the multiple log linear Ordinary Least Square (OLS) regression by considering the Cobb-Douglas production function model. The model is as follows:

$$Y = \alpha_0 X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} X_6^{\beta_6} X_7^{\beta_7} e^{\beta_8 D_1 + \beta_9 D_2 + \beta_{10} D_3 + \beta_{11} D_4 + u} \quad (1)$$

$$\ln Y = \alpha_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 D_1 + \beta_9 D_2 + \beta_{10} D_3 + \beta_{11} D_4 + u \quad (2)$$

Here, the description of the variables and their expected sign are given in Table 4.

Table 4: Description of variables and expected sign

Variables	Definition	Expected sign
Y = Paddy production	Paddy production (tons)	Dependent variable
X ₁ = Area	Size of the paddy production area (hectares)	+
X ₂ = Farmers	Number of farmers (labour) active in paddy production in Muda Irrigation Area	+
X ₃ = Production damages	Size of area (hectares) paddy damage due to pest attack and disease	-
X ₄ = Rainfall	Average rainfall in the year (mm/annual average)	+
X ₅ = Temperature	Average daily temperature (°C) in the year	-
X ₆ = Number of rainy days	Average number of rainy days per month	+
X ₇ = Annual budget allocation	Allocation of budget (RM) from government for paddy production in Muda Irrigation Area	+
D ₁ = Flood	Flood occurring years (dummy) Yes=1, No= 0	-
D ₂ = Revenue incentives	After introducing revenue incentives by government in the year of 2007 (dummy) Yes =1, No=0	+
D ₃ = New price of rice	After introducing new price of rice in the year of 1990 (dummy) Yes =1, No=0	+
D ₄ = New technology	After introducing tranplanter in paddy production in Muda Irrigation Area in the year of 2000 (dummy) Yes =1, No=0	+

Result and Analysis

To check the stationarity of the time series data, this study conducted the Unit Root test based on the Augmented Dickey-Fuller (ADF) and Philip Peron (PP) methods (Table 5). The variables used in the study are found stationary at levels of 1 to 10 percent significance.

Table 5: Output of Unit Root test

Variables	Method	Value	Critical value		
			1%	5%	10%
Y	ADF	Intercept	-0.452	-3.68	-2.97
		Trend and Intercept	-5.031 * * *	-4.31	-3.57
	PP	Intercept	-0.605	-3.68	-2.97
		Trend and Intercept	5.082 * * *	-4.31	-3.57
X ₁	ADF	Intercept	-5.494 * * *	-3.68	-2.97

	PP	Trend and Intercept	-6.186 * * *	-4.31	-3.57	-3.22
		Intercept	-5.511 * * *	-3.68	-2.97	-2.62
		Trend and Intercept	-6.502 * * *	-4.31	-3.57	-3.22
X ₂	ADF	Intercept	-8.066 * * *	-3.68	-2.97	-2.62
		Trend and Intercept	-2.851	-4.31	-3.57	-3.22
	PP	Intercept	-10.684 * * *	-3.68	-2.97	-2.62
		Trend and Intercept	-2.293	-4.31	-3.57	-3.22
X ₃	ADF	Intercept	-4.400 * * *	-3.68	-2.97	-2.62
		Trend and Intercept	-5.946 * * *	-4.31	-3.57	-3.22
	PP	Intercept	-4.034 * * *	-3.68	-2.97	-2.62
		Trend and Intercept	-3.993 * *	-4.31	-3.57	-3.22
X ₄	ADF	Intercept	-5.427 * * *	-3.68	-2.97	-2.62
		Trend and Intercept	-5.622 * * *	-4.31	-3.57	-3.22
	PP	Intercept	-5.410 * * *	-3.68	-2.97	-2.62
		Trend and Intercept	-5.607 * * *	-4.31	-3.57	-3.22
X ₅	ADF	Intercept	-2.595 *	-3.68	-2.97	-2.62
		Trend and Intercept	-4.962 * * *	-4.31	-3.57	-3.22
	PP	Intercept	-2.505	-3.68	-2.97	-2.62
		Trend and Intercept	-8.079 * * *	-4.31	-3.57	-3.22
X ₆	ADF	Intercept	-3.480 * *	-3.68	-2.97	-2.62
		Trend and Intercept	-3.415 * *	-4.31	-3.57	-3.22
	PP	Intercept	-3.357 * *	-3.68	-2.97	-2.62
		Trend and Intercept	-3.251 *	-4.31	-3.57	-3.22
X ₇	ADF	Intercept	-3.158 * *	-3.68	-2.97	-2.62
		Trend and Intercept	-4.860 * * *	-4.31	-3.57	-3.22
	PP	Intercept	-3.099 * *	-3.68	-2.97	-2.62
		Trend and Intercept	-4.864 * *	-4.31	-3.57	-3.22

***, **, and * are significant at the 1%, 5% and 10% significance level, respectively

Based on the micro data from the Muda Irrigation Area, this study found several variables that are significant to paddy production (Table 6). The value of R^2 indicates the good fitness of a model. The R^2 is 0.93, which means the independent variables considered under this study can explain 93% of the dependent variable. The Durbin-Watson (DW) value shows that there is no autocorrelation.

Table 6: Regression output

Variables	Coefficient	t-stat	Dummy change (%)	VIF
X ₁	0.852	6.801 * * *		2.164
X ₂	0.647	6.507 * * *		3.653
X ₃	-0.025	-0.069		2.241

X ₄	0.15	2.174 * *		1.345
X ₅	-2.832	-1.932 *		4.133
X ₆	0.45	1.766 *		3.011
X ₇	0.057	6.561 * * *		3.557
D ₁	-0.035	-0.638	-3.58	1.262
D ₂	0.221	6.045 * * *	24.6	1.605
D ₃	0.21	5.219 * * *	23.3	1.34
D ₄	0.052	1.714 *	5.3	1.408
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R ²		0.961		
Adjusted R ²		0.937		
F-Statistic		40.233		
D.W.		2.049		

***, **, and * are significant at the 1%, 5% and 10% significance level, respectively

Two major units of production – land and labour – are found to be statistically significant with paddy production at the 1% significance level. If the land area increases by 1%, the production of paddy will increase by 0.85%; and if the labour increases by 1%, the production of paddy will increase by 0.65%. However, the decrease in the production area in terms of damage to crops due to pest attacks and diseases does not show a statistically significant relationship with paddy production, even at the 10% level. Another core unit of production is technological usage, which shows a statistically significant and positive relationship with paddy production at the 10% level. A 1 unit change in technology will lead to 0.05 unit change in paddy production.

Among the climatic variables, temperature and the number of rainy days are found to be statistically significant at the 1% significance level, with rainfall at the 5% significance level with paddy production. Rainfall and the number of rainy days show a positive relationship but temperature shows a negative relationship with paddy production. A 1% increase in temperature will lead to the reduction of paddy production by 2.83%. A 1% increase in rainfall and the number of rainy days will lead to an increase in paddy production at 0.15% and 0.45%, respectively. However, the study did not find any statistically significant relationship between floods and the total paddy production in the study area.

The factors of external intervention such as government subsidies and market forces also show a statistically significant and positive relationship with paddy production at a 1% significant level. A 1% increase in government budget and a 1 unit change in incentive will

lead to 0.06% and 0.22 unit increase in paddy production, respectively. Moreover, if the market price of paddy increases by 1 unit, the production of paddy will increase by 0.21 unit.

Discussion

There are several empirical studies on climate change and food security. Most of the studies identify and predict the impact of climate change on the world, especially in terms of food production. Various previous studies have also predicted and measured the changes in agriculture due to climate change in Malaysia based on macro studies (Ali & Ali, 2009; Tilman et al., 2002; Socolow, 1999; Alexandratoss, 1999; Reilly, 1999; Schimmelpfenning et al., 1996; Singh et al., 1996; Penning de Vries, 1993). This study is based on the micro data on the Muda Irrigation Area to find out the more rigorous impacts of climatic changes and government interventions on paddy production in Malaysia.

This study found that climatic factors have impacts on the paddy production in the Muda Irrigation Area. If the temperature increases, the paddy production will decline further in the future. Several studies have also found similar results as mentioned above. Rainfall shows a positive relationship with paddy production, but if the number of rainy days increases, it will damage the crops and cause floods. In 2005, the incidence of flooding had resulted in damages to 18,246.16 hectares of crops, which involved 10,575 farmers, and the government provided assistance of RM 39.3 million to the affected farmers in this area (MADA, 2010).

Government intervention through providing subsidies, incentives, and buying paddy from farmers at a high price has significant impacts on paddy production in the area. These subsidies involve cash benefits for utilizing land for paddy production, providing raw materials such as seeds, fertilizer, and pesticide, and developing the infrastructures related to paddy production including irrigations, dams, roads, machinery support, etc. (Alam et al., 2010a). Government intervention is still needed because the cost of paddy production in the country is still higher compared to importing paddy. If the government reduces or discontinues the assistance, it will adversely affect the paddy production in Malaysia (Alam et al., 2011b).

The production of paddy also depends on various other factors such as timing of water and fertilizer usage, control and monitoring of pests and diseases, harvesting on time, etc. At the same time, to improve the production of paddy, farm management practices and supporting services such as supply of water, fertilizer, and pest control service, etc. should be timely. The production practices of farms and individual farmers also need to be updated with the changes of climate factors such as applying crop rotation, crop portfolio, crop substitutions, etc. (Alam et al., 2010b). For long term sustainability of the paddy production, introducing new technology and the adoption of technology by farmers are very important. At the same time, mitigation options should be followed up at the policy level.

Conclusions

Climate is changing all over the world, but the phases of changes and effects are different among areas and sectors. Agricultural productions as well as the socioeconomic status of farmers are significantly affected due to the climate change in Malaysia. Therefore, to combat the climatic effects, government bodies are providing subsidies and incentives, which are also increasing day by day. However, there are no proper alternative mitigation and adaptation programs to make this sector sustainable and to improve the livelihood in the long run. Mitigation is a macro issue involving a long term, expensive process, but not sufficient to avoid the significant impacts of climate change (IPCC, 2007). It is therefore important to balance the measures against the causes of climate change and the measures to cope with its adverse effects (Stern, 2007; Pielke et al., 2007).

In the micro level, adaptation is essential for agricultural and livelihood sustainability in Malaysia. Adaptation approaches need to be followed at the individual farmer level and policy level through technological developments, government programs, farm production practices, and farm financial management (Smit & Skinner, 2002). Adaptations will be highly dependent on technology in the long-run and financial protection in the short-run. While focusing on financial protection, the government needs to make proper subsidy policies to ensure the SSL production and financial sustainability of the farmers and their farms. Good Agricultural Practices (GAP) should be regularly updated in addition to ensuring co-operation among different groups, stakeholders, and agencies that are critical to cope better with the changing nature of the climate.

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