Journal of Tropical Agriculture 61 (1): 123-126, 2023

Climate risk in Wayanad district: An empirical analysis

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Received 21 August 2022; received in revision form 21 April 2023; accepted on 13 May 2023

Abstract

Risk is an integral part of agriculture and farmers face different types of risks throughout crop production. The uncertainties in weather parameters always cause production risk in agriculture, thereby affecting the welfare of farm households. Climate change and the associated natural calamities have further worsened the already climate-risk-prone agricultural sector. Wayanad is a high-range district in Kerala known for agrarian distress due to natural calamities like floods and droughts. The present study is focused on analyzing the climate risk in Wayanad district, primarily caused by temperature and precipitation. Using the Just and Pope production function, the influence of climatic parameters, along with acreage, on the production and production variability of five major crops in the district, namely coffee, arecanut, rubber, coconut and black pepper were estimated. The results showed a significant negative influence of standard deviation in temperature and standard deviation in precipitation on the production of coffee and black pepper respectively. The average temperature in a year was found to significantly increase the production of coconut, whereas it decreased rubber production. No significant influence of climatic parameters was found on the production of arecanut. The Just and Pope variance function showed no significant influence of climatic parameters on the production variability of any of the five crops under study.

Keywords: Climate, Climate risk, Risk function, Variability, Wayanad

Introduction

Agriculture is one of the riskiest economic activities and perhaps the most vulnerable to climate change and natural calamities (World Bank, 2015). The high dependency on weather parameters makes crop production a highly uncertain process. Climate change, directly and indirectly, affects the cultivation of plantation crops like coffee, arecanut, rubber, coconut and tea in the forms of biotic stresses like pest and disease attacks, and abiotic stresses like floods and droughts (Hebbar et al., 2016). Wayanad is predominantly an agriculture-oriented district with plantation crops like coffee, arecanut, rubber, coconut, tea and black pepper occupying 75 per cent of the gross cropped area (GoK, 2019). The district is also susceptible to water scarcity and occasional droughts, which makes the cultivation of crops even more risky (Varghese, 2012). Identifying the influence of climatic parameters in crop production and its variability helps devise appropriate risk management strategies for the farmers. Adapting to climate change is challenging, especially for a state like Kerala where the land holding size is marginal. The smaller size of land holding, lower educational status and lesser adaptive capacity make the farm households in developing countries like India highly vulnerable to changing climate (Tripathi and Mishra, 2017). Hence, the study aimed to identify the influence of climatic parameters on

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the production and production variability of major crops in the district *viz.,* coffee, arecanut, rubber, coconut and black pepper.

Materials and methods

The study is based on time series data on production and area under coffee, arecanut, rubber, coconut and black pepper, and climatic parameters like average annual precipitation, average annual temperature and the standard deviations in precipitation and temperature in Wayanad district from 1983-84 to 2018-19. The data on the production of crops were obtained from Statistics for Planning and Agricultural Statistics published by the Directorate of Economics and Statistics, Government of Kerala. The data on precipitation and temperature for Wayanad district were collected from Regional Agricultural Research Station, Ambalavayal and the daily gridded temperature data set (Srivastava *et al*., 2009) respectively.

The study used the Just and Pope production function to estimate the influence of climatic parameters on the production and production variability of major crops in the Wayanad district. Just and Pope (1978) proposed a stochastic production function that relates the independent climatic variables and acreage with the probability distribution of crop production. The major advantage of this method is that there is no dependency on the independent item's effect on average production or production variability (Chen et al., 2004). In this study, the Just and Pope production function, as used by Arumugam et al. (2014) was used to statistically determine how production and its variance were influenced by climate. The production function used is:

$$Y_{it} = f(X_{it}, \beta) + h(X_{it}, \alpha)\varepsilon_{it}$$

Where,

Y_{it} is the crop production at time 't'

X_{it} represents the set of independent variables (acreage and climate at time 't')

$f(\cdot)$ is the average production function

$h(.)$ is the variance/ risk function

The functional form $h(\cdot)$ for the error term is an explicit form for heteroscedastic errors, allowing estimation of variance effects. Estimating the parameters β and α, the average effect of climatic variables on production and the effect of each climatic variable on the variance of the crop production are obtained respectively. After estimating the parameters of $h(\cdot)$, the interpretation could be made by looking at the sign of those parameters. A positive sign in the parameter implies that an increase in that variable will increase the variance of crop production, while a negative sign implies the opposite.

The linear average production function is given as:

$f(X; \beta, d) = \beta 0 + \beta 1\ Acreage + \beta 2\ Temperature + \beta 3\ SD\text{-}Temperature + \beta 4\ Precipitation + \beta 5\ SD\text{-}Precipitation$

The semi-log linear form of the variance function is represented as:

$\ln h^2 (X; \beta, \eta) = \delta 0 + \delta 1\ Acreage + \delta 2\ Temperature + \delta 3\ SD\text{-}Temperature + \delta 4\ Precipitation + \delta 5\ SD\text{-}Precipitation$

Where,

$\ln h^2 (x; \delta, \eta)]$ is the logarithm of squared residuals from the first stage OLS

The average production function in the Just and Pope production function was estimated using Weighted Least Squares (WLS) method with the predicted standard deviations as weights. The variance function was estimated using the OLS method assuming a semi-log linear form (Arumugam et al., 2014).

The stationarity of variables used in the analysis was checked using the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) plots before the estimation of Just and Pope yield function since the stationarity of variables is an underlying assumption in the model.

Results and Discussion

The influence of climatic parameters on production and variability in the production of five major crops in Wayanad district were estimated. The results of WLS estimates of average production function show the influence of climatic parameters on the production of these crops, while the OLS estimates of risk function show the influence of climatic parameters on production variability.

Influence of climate on production

The results of the average production function of coffee, arecanut, rubber, coconut and black pepper estimated using WLS method are given in Table 1. As seen from the results, the area was positively related to production at a one per cent significance level for all the crops. This indicated a clear-cut relationship between the increase in production and the increase in area. Standard deviation in temperature was found to affect coffee production in the district negatively. This was found to be highly significant at a one percent level, meaning higher deviations from the mean temperature in a year can cause a decline in the production of coffee in the district. The standard deviation in precipitation was found to negatively affect the black pepper production in the district at a 10 per cent significance level. This implies that higher rainfall over fewer days in a year can cause a decline in the production of black pepper. In the case of arecanut, no significant relationship was found between any of the climatic variables and the production of arecanut. This suggests that changes in temperature and precipitation in the district over the years were insufficient to influence the average production of arecanut. The mean temperature of the year was found to positively affect the production of coconut and negatively affect the production of rubber, both at a one percent significance level. The inference from this result is that an increased average temperature in a year increases the coconut production in the district while decreasing rubber production.

Influence of climate on production variability

The results of the log production variance regression are given in Table 2. The area under the crop was found to positively influence the production variability in black pepper and arecanut at five percent level and 10 percent levels respectively. Large farms are more vulnerable to yield losses as they require more inputs or factors and better management practices. Any risk will have a greater

Table 1. Estimates of average production function –Two-stage WLS with predicted standard deviations as weights

Independent variables	Coffee		Black pepper		Arecanut		Coconut		Rubber	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Area (Hectares)	0.966***	0.263	0.352***	0.045	0.481***	0.039	0.006***	0.001	1.21***	0.102
Mean Temperature (ºC)	11304.8	8568.197	-3343.58	2258.55	626.867	553.267	21.438***	6.478	-3230.9***	915.868
SD Temperature (ºC)	-50328.9***	14312.79	-1563.84	4021.819	114.512	1055.186	1.839	12.907	1650.169	1454.077
Precipitation (mm)	-15.692	12.903	-0.311	2.866	0.727	0.816	0.01	0.01	-0.881	0.983
SD Precipitation (mm)	137.112	113.644	-4.609*	28.503	-10.579	7.189	-0.008	0.084	4.729	8.746
Constant	-206679.0	204958.3	84402.86	54119.98	-15075.87	13294.37	-556.49***	155.17	72828.88***	20994.27

***Significant at one percent level * Significant at 10 percent level

Table 2. Estimates of log production variance regression

Independent variables	Coffee		Black pepper		Arecanut		Coconut		Rubber	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Area (Hectares)	0.0	0.0	0.001**	0.001	0.0*	0.0	0.0	0.0	0.0	0.0
Mean Temperature (ºC)	-1.417	1.242	0.775	1.658	-0.319	1.092	0.145	1.328	1.196	2.892
SD temperature (ºC)	-0.129	2.217	-0.590	3.029	-3.592	1.981	-2.108	2.573	0.929	4.621
Precipitation (mm)	-0.001	0.002	-0.001	0.003	-0.001	0.002	0.0	0.0	0.0	0.0
SD Precipitation (mm)	0.003	0.016	0.001	0.002	0.015	0.014	0.014	0.018	0.014	0.029
Constant	55.718*	29.686	-4.079	40.976	25.140	26.128	2.405	31.660	-21.583	66.038

***Significant at one percent level * Significant at 10 percent level impact on them than on smaller farms. Interestingly, no significant relationship was established between the climatic parameters and variance in the production of any of the crops. Even though climatic parameters were found to influence the production of crops, they had no significant influence on their production variability. The temperature and rainfall data of Wayanad district from 1983 to 2019 do not show significant variations among the climatic parameters over those years. Therefore, it is normal to expect no significant influence of them on the production variability. Also, droughts in many regions of Wayanad during the initial years of the new millennium and the floods of 2018 and 2019 need to be considered as isolated cases and not significant enough to influence the production variability in the long run.

It is important to know about the study's limitations before drawing any conclusions from it. The average climatic data used in this study does not give much idea about the intra-annual variations in the weather parameters. For crops like coffee, the timing of receipt of summer showers is very crucial and it influences the production of the crop. So, climate change-induced variations in the intra-annual weather parameters go beyond the scope of the present analysis. The assumption that the climatic data obtained from RARS Ambalavayal represents the whole district is also quite limiting. A better picture of the influence of climatic parameters on the production variability of the crops could be drawn if weather data at Panchayat or block level were made available. Within the constraints of this analysis, it could be concluded that the climatic parameters influence the production of coffee, black pepper, coconut and rubber in Wayanad district, but do not influence their production variabilities.

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