

Time Series Trend Analysis of the Effect of Rainfall on the Productivity of Cayenne Pepper (*Capsicum frutescens* L.) in Southeast Sulawesi Province

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Abstract

*Climate change occurs due to changes in climate elements such as wind, air humidity, temperature and rainfall. Climate change is caused by natural events and human activities, which threaten the agricultural sector and food security, impacting humans and crops. The affected agricultural sector, including the horticulture subsector, experienced a decline in production and farmer income. One of the affected horticultural commodities is cayenne pepper (*Capsicum frutescens* L.), which is important for fulfilling people's nutrition. This research aims to: (1) Find out the productivity of cayenne pepper in Southeast Sulawesi Province, and (2) Analyze the effect of rainfall on the productivity of cayenne pepper in Southeast Sulawesi Province. The data used in this research is secondary data, obtained from the Southeast Sulawesi Provincial Plantation and Horticulture Service and the Southeast Sulawesi Central Statistics Agency (BPS). The data in this study were analyzed using simple regression. The research results show that the productivity of cayenne pepper in Southeast Sulawesi Province from 1993-2023 is 29,784 Ku/Ha, varying from year to year. The estimation results of the regression equation model show that rainfall has no effect on cayenne pepper productivity.*

Keywords: Rainfall; Productivity; Cayenne Pepper.

INTRODUCTION

Rainfall amount is the height of rainwater that falls on a flat area assuming the water does not penetrate, flow, or evaporate. Indonesia, as a tropical country, has high annual rainfall,



especially in mountainous areas (Mulyono, 2014). According to Tjasyono (2004), climate change occurs due to changes in climate elements such as wind, air humidity, temperature, and rainfall. Currently, climate change caused by natural phenomena and human activities threatens the agricultural sector and food security, affecting people and plants. The impact is felt in the horticulture subsector, which has experienced a decline in production and farmer income. One of the affected horticultural commodities is cayenne pepper (*Capsicum frutescens* L.), which has an important role in fulfilling community nutrition.

Chili is a horticultural commodity that is popular with the public because it has high nutritional and economic value. Chili is used as a seasoning and raw material for the food, beverage, and medicine industries, making it a strategic commodity to be developed commercially in the tropics. The increasing market demand along with population and industry growth causes the price of red chili to fluctuate greatly, depending on the availability of supply and demand (Prayitno et al., 2013). Cayenne pepper is also rich in vitamins and nutrients such as vitamins A, B1, B2, C, protein, fat, carbohydrates, phosphorus, iron, and calcium, so it is much in demand and consumed by the community (Sujitno and Dianawati, 2015). As an agrarian country, Indonesia relies on the agricultural sector, which plays an important role in the national economy. The sector is divided into five main subsectors: food crops and horticulture, plantations, livestock, forestry, and fisheries (Mubyarto, 1995; Santika, 2012).

Southeast Sulawesi has an area of 3,814,000 ha with potential agricultural land resources that include 3,147,000 ha of dry land, dominated by FMD land at 60.3% (Kartono, 2002), and 944,148 ha of paddy fields, of which 44.9% (423,794 ha) has not been utilized. This shows great potential for the development of the agricultural sector, despite the constraints of labor shortages. In 2022, the population of Southeast Sulawesi reached 2,701,661 people with a labor force of 1,382,395 people (BPS Southeast Sulawesi, 2022). The region covers a land area of 38,067.7 km² with mountainous and hilly topography, and a sea area of 110,000 km² (74 percent) (BPS Southeast Sulawesi, 2016). Agriculture dominates Southeast Sulawesi's GRDP structure with a contribution of 24 percent, and 45 percent of the total population works in this sector. One of the efforts to increase horticultural production such as cayenne pepper is proper watering, because water plays an important role in the absorption of plant nutrients (Sinaga, 2007). However, changes in rainfall can affect the productivity of cayenne pepper, especially if the planting time is inappropriate, which increases the risk of crop failure and pest and disease attacks. The following is data on land area, production and productivity of cayenne pepper in Southeast Sulawesi based on data from the Southeast Sulawesi Plantation and Horticulture Office:



Table 1 Harvested Area, Production and Productivity of Cayenne Pepper in Southeast Sulawesi Province in 2019-2023

No.	Year	Area (Ha)	Production (Qu)	Productivity (Ku/Ha)
1	2019	1.320	36.686	27,792
2	2020	1.439	38.014	26,416
3	2021	1.266	43.934	34,703
4	2022	1.420	39.145	27,566
5	2023	1.572	45.168	28,732
Total		7.017	2-2.947	145,209
Average		1.403	40.589	29,041

Data Source: Plantation and Horticulture Office Prov. Southeast Sulawesi

Table 1 shows that the highest productivity of cayenne pepper in Southeast Sulawesi occurred in 2021 with a yield of 34,703 Ku/Ha, indicating each hectare of land produced 34,703 quintals of cayenne pepper. Factors such as ideal weather conditions, improved farming techniques, and optimized farming inputs may have contributed to this achievement. In contrast, the lowest productivity occurred in 2020 with 26.416 Ku/Ha, which was caused by challenges such as unfavorable weather and pest attacks (BPS Sultra, 2023). Meanwhile, monthly rainfall data for 2022 from four meteorological stations in Southeast Sulawesi - Kendari Maritime Meteorological Station, Beto Ambari Baubau, South Konawe Climatology, and Sangia Ni Bandera Kolaka - are presented in Table 2 to provide an overview of climatic conditions that affect agricultural productivity.

Table 2 Total Rainfall by Month in Southeast Sulawesi Province in 2022

District/City <i>Regency/Municipality</i>	Kendari Maritime Meteorologi cal Station	Beto Ambari Baubau Meteorologi cal Station	Southeast Sulawesi Climatology Station South Konawe	SangiaNi Bandera Meteorologic al Station Kolaka
January	121,90	164,40	140,90	101,50
February	252,10	380,10	179,10	299,30
March	264,90	291,20	320,00	352,90
April	90,20	98,70	218,90	306,90
May	132,00	177,10	196,70	215,10

June	193,20	495,10	255,40	201,70
July	233,90	18,10	386,30	128,00
August	177,00	118,90	265,70	254,60
September	177,00	62,60	337,00	237,00
October	94,10	211,10	98,60	306,00
November	155,60	273,80	157,60	149,00
December	263,10	350,00	139,20	171,80

Source: Southeast Sulawesi Meteorology, Climatology and Geophysics Agency Year 2022

The data in Table 2 show significant variations in rainfall between stations and months of the year. Rainfall in Southeast Sulawesi Province undergoes different changes over a period of time that cannot be predicted. Beto Ambari Baubau Meteorological Station had the highest rainfall in February, while Sangia Ni Bandera Kolaka Meteorological Station recorded the lowest rainfall in July. Seasonal patterns in Southeast Sulawesi Province are also evident, where months such as March and June tend to be wetter, while August and October tend to be drier. This information is important for agricultural planning, water resources management, and understanding the climate in the region, as well as for anticipating disaster risks and adapting to climate change (BPS Southeast Sulawesi, 2022).

METHOD

The type of data used in this research is secondary data. The source of data comes from the Department of Plantation and Horticulture of Southeast Sulawesi Province and the Central Bureau of Statistics (BPS) of Southeast Sulawesi for the last 30 years (1993-2023). Data collection techniques in this study, which is done by recording (imputation), the data obtained is from the relevant agencies derived from the Department of Plantation and Horticulture of Southeast Sulawesi Province and Southeast Sulawesi Central Bureau of Statistics. The data analysis used is presented below:

1. To determine the productivity of cayenne pepper, it is analyzed using productivity analysis. According to Gasperz (2008), the productivity equation used is :

$$\text{Productivity} = \frac{\text{Jumlah Produksi (Ku)}}{\text{Luas Lahan (Ha)}} \dots\dots\dots(4)$$

2. Seeing the effect of rainfall on cayenne pepper productivity was analyzed using simple regression. According to Sujana (2005) the simple linear regression equation, namely:

$$Y = a + bX \dots\dots\dots(5)$$

Description:

Y= productivity (Ha)

a= constant (a)

b= regression coefficient (b)

X= rainfall (mm)

RESULTS AND DISCUSSION

Rainfall Conditions in Southeast Sulawesi Province

Rainfall is the amount of rainwater that falls on a flat surface during a certain period, measured in units of height (mm) above the horizontal surface without evaporation (Kasni, 2021). Cayenne pepper plants require direct sunlight and ideal rainfall levels between 250-5000 mm per year to grow optimally. In Southeast Sulawesi Province, rainfall shows variations throughout the year, influenced by tropical climate patterns and monsoon winds. The rainy season usually lasts from November to March with high rainfall, while the dry season occurs from April to October. Changes in rainfall over the past 30 years (1993-2023) in the region provide important insights for the agriculture and planning sectors regarding the impacts of climate change on rainfall patterns.

Table 3 shows that the highest rainfall in Southeast Sulawesi Province was recorded in 2007, with some areas such as Baubau, Raha and Kendari reporting rainfall figures above 3,000 mm. The average rainfall in that year reached around 1,000 mm, reflecting a very high rainfall intensity. This high rainfall is beneficial in providing abundant water supply for agriculture, but can also cause problems such as flooding, soil erosion and increased risk of plant diseases due to excess moisture. In contrast, the lowest rainfall was recorded in 1997, with areas such as Baubau and Raha reporting figures of around 478 mm to 667 mm. The average annual rainfall in that year only reached 58 mm to 258 mm, potentially causing drought and reducing water availability for crops, thus affecting agricultural growth and productivity. Data on average annual rainfall in Southeast Sulawesi Province for the period 1993-2023 can be seen in Table 3.

Table 3 Average Rainfall for 1993-2023 in Southeast Sulawesi Province

Year	A	B	C	D	E	F	Amount (mm)	Average
1990	1.236	732	2.17	1.223			736.629	184.157
1991	906	1.152	1.479	320			1.228.631	307.157
1992	1.061	1.056	2.002	317			1.679.771	419.942
1993	713	799	2.771	165			1.679.771	419.942
1994	741	1.207	2.315	185			929.522	232.380

1995	1.881	1.942	2.742	229			235.565	58.891
1996	1.383	834	2.636	197			1.035.019	258.754
1997	478	667	1.223	106			1.252.223	313.055
1998	1.153	1.456	2.554	271			276.163	69.040
1999	1.984	1.456	2.109	262			267.549	66.887
2000	1.91	686	2.517	237			927.427	231.856
2001	1.91	686	1.6	161.64			851.150	212.787
2002	1,910	686	1.763	161.64			2.759	689.850
2003	1,910	686	1.592	183.69			2.781.282	695.320
2004	1,196	1.236	1.556	177.6			1.376	344.098
2005	1.196	1.286	2.851	245.75			251.083	62.770
2006	1.906	1.185	1.747	155.48			160	40.079
2007	3.217	2.274	3.466	285	2.366	3.217	299.540	74.885
2008	3.217	2.274	3.466	285.19	2.366	3.217	300	74.932
2009	1.863	4.648	2.301	1.844	2.301	3.217	16.174	2.695
2010	1.093	4.648	1.419	1.788	1.782	10.07	20.800	3.466
2011	3.149	2.602	2.859	3.951	3.648	3.432	19.641	3.273
2012	2.114	970	1.511	1.58	2.427	2.705	980.337	163.389
2013	1.833		1.549	1940			1.945.435	324.239
2014			2.636				2.636	2.636
2015			2.263				1.595	1.595
2016	1.468		1.595				5.246	1.748
2017	2.063		2.113				6.746	2.248
2018	2.922		2.913				10.435	3.478
2019	1.912		2.387				7.478	2.492
2020	1,238		1.987	1.592	2.002		1,244	310.895
2021	2.082		2.416	1.973	2.591		9.062	2.265
2022	2.353		2.141	2,491	2.767		2498.261	624.565
2023	2,611		2.128	2.723	2.695		2,619	654.636

Source: Central Bureau of Statistics of Southeast Sulawesi Province, 2023

Description: A= Bau-Bau (Buton), B = Raha (Muna), C = Kendari, D = Pomalaa (Kolaka), E = Andoloo (South Konawe), F = Wajo Market (Buton)



1. Annual Rainfall in Southeast Sulawesi Province

The results of the analysis of annual rainfall in Southeast Sulawesi Province from 1990 to 2023 show significant variations, with the lowest rainfall recorded in 2015 at 1,595 mm and the highest in 2003 reaching 695,320 mm. Some years show very low rainfall, such as the period 2009 to 2011 with values below 5 mm, while years such as 2002, 2003 and 2023 recorded rainfall exceeding 600 mm. The average annual rainfall during the period was about 191,907 mm. This variability reflects large year-to-year changes, which are likely influenced by atmospheric conditions, global climate change and local weather phenomena, thus confirming the significant weather dynamics in the region.

2. Monthly Average Rainfall in Southeast Sulawesi Province

The results of the analysis of average monthly rainfall in Southeast Sulawesi Province from 1990 to 2023 show a seasonal pattern consistent with a tropical climate, where the rainy season (November to April) produces significant rainfall, with peaks in December to February as in 2002 and 2003 which recorded monthly averages of up to 695.320 mm. In contrast, the dry season (May to October) shows minimal rainfall, as in 2009 to 2011 with a monthly average of only about 2.7 mm. This pattern illustrates the major challenges in water resources management and agriculture, as well as the need for planning and adapting to climate change for disaster risk mitigation such as floods and droughts in the region.

3. Development of Harvested Area, Production & Productivity of Cayenne Pepper

The development of land area, production, and productivity of cayenne pepper in Southeast Sulawesi based on data from the Southeast Sulawesi Central Bureau of Statistics and the Southeast Sulawesi Plantation and Horticulture Office can be seen in Table 4.

Table 4 Harvested Area, Production and Productivity of Cayenne Pepper in Southeast Sulawesi Province 1993-2023

No.	Year	Harvested Area (Ha)	Production (Qu)	Productivity (Ku/Ha)
1	1993	629	3.534	5,618
2	1994	497	2.055	4,134
3	1995	487	10.471	21,501
4	1996	437	10.674	24,425
5	1997	485	22.244	45,863
6	1998	582	12.020	20,652
7	1999	788	11.366	14,423

8	2000	597	16.593	27,793
9	2001	691	26.301	38,062
10	2002	987	30.119	30,515
11	2003	1.051	14.748	14,032
12	2004	1.142	30.031	26,296
13	2005	779	27.912	35,830
14	2006	685	15.824	23,100
15	2007	613	14.738	24,042
16	2008	474	11.641	24,559
17	2009	790	27.834	35,232
18	2010	1.438	47.814	33,250
19	2011	758	25.262	33,327
20	2012	1.497	40.855	27,291
21	2013	1.080	48.853	45,234
22	2014	1.176	67.876	57,717
23	2015	1.045	35.922	34,375
24	2016	1.046	80.018	76,499
25	2017	1.460	33.129	22,691
26	2018	1.400	44.842	32,030
27	2019	1.320	36.686	27,792
28	2020	1.439	38.014	26,416
29	2021	1.266	43.934	34,703
30	2022	1.420	39.145	27,566
31	2023	1.572	45.168	28,732
	Total	29.631	915.623	923,309
	Average	955,838	29.536	29,784

Data Source: Plantation and Horticulture Office of Southeast Sulawesi Province, 2023

Table 4 shows data on land area, production, and productivity of cayenne pepper in Southeast Sulawesi Province from 1993 to 2023, reflecting significant developments in the cayenne pepper agricultural sector over the past three decades. The harvested area of cayenne pepper varied from 437 ha in 1996 to a peak of 1,438 ha in 2010. Cayenne pepper production has also increased, from 3,534 Ku in 1993 to a peak of 80,018 Ku in 2016, although the lowest production was recorded in 1994 with only 2,055 Ku, despite a land area of 497 Ha. Cayenne

pepper productivity, calculated as production per hectare (Ku/Ha), increased from 5,618 Ku/Ha in 1993 to a peak of 76,499 Ku/Ha in 2016, although there were fluctuations as in 2003 and 2017. This data shows a positive trend in land area, production, and productivity of cayenne pepper, which is influenced by various factors, including favorable climatic conditions. This analysis is important for understanding the dynamics of agriculture in the region and designing policies and strategies to support the sustainable growth of the agricultural sector in the future.

Productivity of Cayenne Pepper in Southeast Sulawesi Province

Based on the productivity data of cayenne pepper in Southeast Sulawesi from 1993 to 2023, the highest productivity was recorded in 2016 at 76.50 Ku/Ha, which was influenced by improved seed quality, optimal land management, and favorable climatic conditions, while the lowest productivity occurred in 1994 with only 4.13 Ku/Ha, which was likely influenced by low soil fertility and pest attacks. The variation in productivity between regions is also significant, with North Konawe recording the highest productivity of 31.27 Ku/Ha despite a harvest area of only 44 ha, followed by Baubau City (17.6 Ku/Ha) and South Buton (13.7 Ku/Ha). In contrast, regions such as North Kolaka (1.35 Ku/Ha) and East Kolaka (1.73 Ku/Ha) have low productivity. One of the areas with development potential is North Kolaka Regency, especially in Pakue Tengah Sub-district, which has become one of the cayenne pepper centers although its production has fluctuated in the last five years, such as a decrease from 1,949 Ku in 2019 to 1,382 Ku in 2020. This data shows the need to optimize production and resource management to increase the productivity of cayenne pepper sustainably in Southeast Sulawesi.

This can be due to the reduction in the cayenne pepper harvest area. In 2021, the production of cayenne pepper has increased to 2,085 Ku. The production of cayenne pepper which still depends on the season, resulting in fluctuations in the amount of cayenne pepper production between harvest seasons which causes a very abundant supply of cayenne pepper during the harvest season.

Table 5 Harvested Area, Production, and Productivity of Raw Chili in North Kolaka Regency in 2017-2021

No.	Year	Harvested Area (Ha)	Production (Qu)	Productivity (Ku/Ha)
1	2017	169	2.041	12,076
2	2018	223	2.936	13,165
3	2019	158	1.949	12,335
4	2020	132	1.382	10,469

5	2021	102	2.085	20,441
	Total	784	10.393	12.132
	Average	156,8	2.078,6	2.426

Source: Central Bureau of Statistics of North Kolaka Regency, 2022

The highest productivity of cayenne pepper in North Kolaka Regency was in 2021 at 20,441 Ku/Ha and the lowest in 2020 at 10,469 Ku/Ha, with an average of 12,132 Ku/Ha. Although the land area in 2020 was larger (132 Ha), the productivity was lower than in 2021 (102 Ha). More optimized land use in 2021 resulted in higher production of 2,085 Ku compared to 1,382 Ku in 2020.

Effect of Rainfall on Cayenne Pepper Productivity

According to Sugiyono (2011), simple linear regression analysis is a statistical method for measuring the relationship between dependent and independent variables, by finding the best straight line that represents the relationship. In this study, this analysis is used to test the effect of rainfall (independent variable) on cayenne pepper productivity (dependent variable). Based on the results of data analysis, the regression equation is obtained as follows:

$$Y = a + bX$$

$$Y = 31,049 - 8,875$$

The model estimation results show that the constant obtained is 31.049. This positive constant value indicates that if there is no rainfall (X_1), then the productivity of cayenne pepper is 31.049. That is, 31.049 is the value of cayenne pepper productivity when the rainfall variable is equal to zero. Without rainfall, there are several other ways that farmers can provide the water needed by plants, such as making reservoirs and wells.

1. Determinance Test (R^2)

The model estimation results show a coefficient of determination (R^2) value of 0.014, which means that rainfall only explains 1.4% of the variability in cayenne pepper productivity, while 98.6% is influenced by other factors not studied. Cayenne pepper productivity is highly dependent on factors such as seed quality, soil conditions, and climate. Superior seeds that are pest-resistant (Sutoyo, 2015), fertile soil with proper fertilizer management (Sarwono, 2017), and optimal temperature, rainfall, and sunlight (Nurhayati, 2018) are important elements in increasing productivity. Additional factors such as spacing, irrigation, and pest control also play a significant role (Rahmawati, 2019). The low coefficient of determination indicates that this study is not representative because it ignores other important

variables such as air humidity, sunlight, wind speed, and organic fertilizer use, which have been shown to affect productivity in previous studies.

2. T-test/Partial Test

The results of the t statistical test showed that the significance value of the rainfall variable was 0.528, which was greater than 0.05, so that rainfall did not have a significant effect on the productivity of cayenne pepper. This can be caused by various factors, such as inundation due to excessive rainfall, which inhibits flower and fruit formation (Prastowo & Sulistyaningsih, 2017), as well as a lack of fulfillment of nutrient needs and optimal fertilizer use. Excessive rainfall can damage roots and increase the risk of diseases on roots and leaves, while lack of rain can cause drought that inhibits plant growth (Dermawan, 2010). Therefore, good irrigation management is important to support the productivity of cayenne pepper, especially since the crop is sensitive to heavy rains and waterlogging.

CONCLUSION

Based on the results and discussion in this study, it can be concluded that the average productivity of cayenne pepper in Southeast Sulawesi Province over the past 30 years (1993-2023) is 29.784 Ku/Ha. Rainfall has no significant effect on the productivity of cayenne pepper in Southeast Sulawesi Province.

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