

IMPACT OF CLIMATIC FACTORS AND AREA ON RICE CROP PRODUCTION

Chebrolu Snehit, Alapati Bipin, Abhiram Karumathil

Ecole Nationale de l'Aviation Civile

January 19, 2024

Presentation overview

- 1 Introduction
- 2 Literature review
- 3 Methodology
- 4 First Regression Model
- 5 Final Regression Model
- 6 Conclusion
- 7 References

Question

What are the factors affecting rice crop production?

Area under consideration

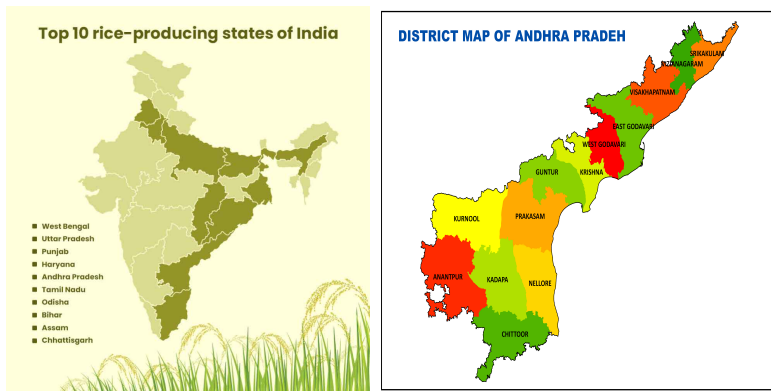


Figure: India & Andhra Pradesh

Results

Districts	R- squared	Prob(F-statistic)	Jarque-Bera (normality) test	Variables affecting the crop yield
Krishna (Krishna zone)	0.39	0.17	0.72	2
Kurnool (scarce rainfall zone)	0.89	0	0.50	1
Chittoor (southern zone)	0.80	0	0.7	2
Vizianagaram (north coastal zone)	0.84	0	0.884	2
West Godavari (Godavari zone)	0.50	0.05	0.84	1

Figure: Regression analysis results

Introduction

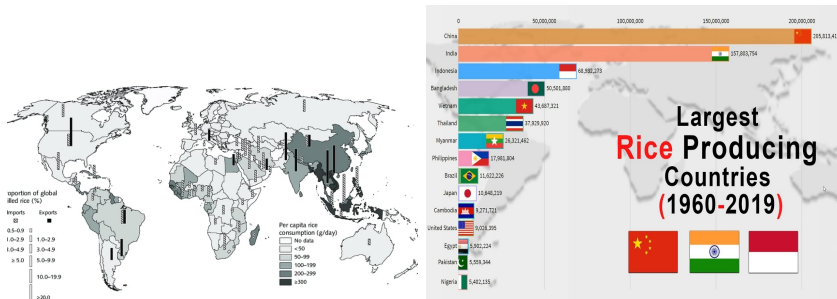


Figure: Global rice consumption and production

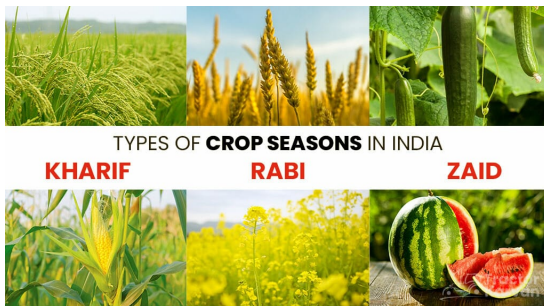
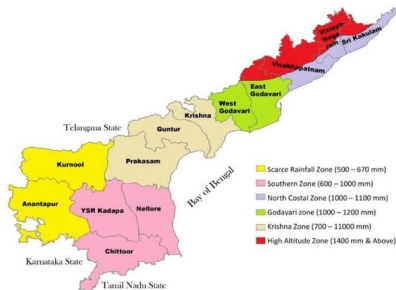
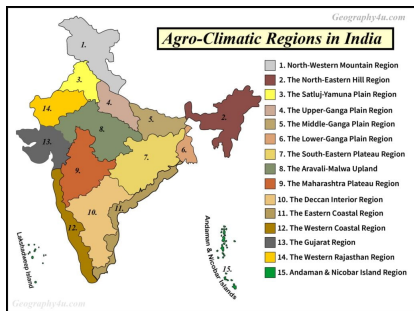


Figure: Crop seasons in India

- Andhra Pradesh (a state in India) is considered **India's rice bowl**.
- Andhra Pradesh has **six** agro-climate zones (suitable for certain crops to grow) with 13 districts.
- **1. Scarce Rainfall Zone. 2. Southern Zone. 3. North Coastal Zone. 4. Godavari Zone. 5. Krishna Zone. 6. High Altitude Zone.**
- **Five districts** covering all six zones are selected for this study.
- The districts selected are Krishna, Kurnool, Chittoor, West Godavari, Vizianagaram, which are the primary producers in their particular zones.

Characterization of the study site



North coastal zone: Srikakulam, **Vizianagaram**, Visakhapatnam

Godavari zone: East Godavari and **West Godavari**

Krishna zone: **Krishna**, Guntur, Prakasam

Southern zone: **Chittoor**, YSR Kadapa, and SPS Nellore

Scarce rainfall zone: **Kurnool** and Anantapur

High altitude zone: Srikakulam, Visakhapatnam and **Vizianagaram**

- Farming is a compound output which is equally influenced by **Natural factors** (Climate, Soil Topography, Terrain) and **Artificial Factors** (Pesticides, Labour, Capital, Technology etc..).
- From the research data, Crop production are significantly impacted by **climate** for rice, tobacco and groundnut in Andhra Pradesh.
- This study covers the impact of Climatic factors and Area on the production of rice crops in Andhra Pradesh.
- The considered factors are Area under Cultivation, Rainfall, Soil wetness, Precipitation, Wind speed, Temperatures (Average).
- This Regression analysis is performed to get a better understanding of the influence of **Area and Climatic factors** affecting the rice cultivation.

- Padakandla, Steven Raj. "Climate sensitivity of rice yields: an agro climatic zone analysis in the undivided state of Andhra Pradesh, India." *Journal of Public Affairs* 21.3 (2021): e2261.
- Mundfrom, Daniel J., et al. "Multiple Linear Regression Viewpoints." (2006): 1-6.
- Mukherjee, Asis, and A. K. S. Huda. "Assessment of climate variability and trend on wheat productivity in West Bengal, India: crop growth simulation approach." *Climatic change* 147.1-2 (2018): 235-252.
- Sellam, V., and E. Poovammal. "Prediction of crop yield using regression analysis." *Indian Journal of Science and Technology* 9.38 (2016): 1-5.
- Climate factors has some impact on rice yield

Assumptions

- Linearity
- Strict exogeneity
- No multicollinearity
- Spherical errors
- Normal errors

- **Least squares estimation**
- **Jarque-Bera**
- **Breusch-Pagan**
- **Centered VIF** (variation inflation factors)
- **Durbin-Watson**

- **Nasa Power and Indian WRIS** - Monthly weather data from June-November (Kharif).
- **Directorate of Economics and Statistics** - The yield, area of cultivation, and production data.

20 years of data is collected from the above-mentioned sources during the time period 2002-2021.

First Regression Model

- $\text{Log}(P) = C + \beta_1 \log(A) + \beta_2 \log(R) + \beta_3 \log(T) + \beta_4 \log(W) + \beta_5 \log(\text{pre}) + \beta_6 \log(\text{sw}) + \mu$

where,

- C is the constant term
- μ is the error term
- $\beta_1 \beta_2 \beta_3 \beta_4 \beta_5$ are the regression coefficients
- P = production of rice(tonnes)
- A = area under cultivation of rice(hectares)
- R = average rainfall over six months(mm)
- T = average temperature(degree)
- W = Wind speed(m/s)
- pre = Precipitation(mm)
- sw = soil wetness

West Godavari District Results

Dependent Variable: LOG(P)
 Method: Least Squares
 Date: 01/17/24 Time: 23:02
 Sample: 2002 2021
 Included observations: 20

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	25.11828	16.84521	1.491123	0.1598
LOG(A)	0.061026	0.898787	0.067898	0.9469
LOG(R)	-0.706954	0.449838	-1.571574	0.1401
LOG(T)	-2.185380	2.853448	-0.765873	0.4574
LOG(W)	-0.851138	1.146555	-0.742343	0.4711
LOG(SW)	0.794203	1.696798	0.468060	0.6475
LOG(PRE)	-0.140181	0.306529	-0.457318	0.6550

R-squared	0.516590	Mean dependent var	13.44971
Adjusted R-squared	0.293477	S.D. dependent var	0.192377
S.E. of regression	0.161703	Akaike info criterion	-0.536899
Sum squared resid	0.339921	Schwarz criterion	-0.188392
Log likelihood	12.36899	Hannan-Quinn criter.	-0.468867
F-statistic	2.315379	Durbin-Watson stat	1.718053
Prob(F-statistic)	0.096380		

Variance Inflation Factors
 Date: 01/17/24 Time: 23:05
 Sample: 2002 2021
 Included observations: 20

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	241.4008	195551.6	NA
LOG(A)	0.755271	93578.28	1.881390
LOG(R)	0.092922	1973.782	4.780050
LOG(T)	4.934595	49578.36	3.356702
LOG(W)	0.862183	393.2900	1.659501
LOG(PRE)	0.083521	191.8663	6.070217

Figure: R-squared and VIF values

Krishna District Results

Dependent Variable: LOG(P)				
Method: Least Squares				
Date: 01/17/24 Time: 23:03				
Sample: 2002 2021				
Included observations: 20				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.822828	12.98492	-0.217393	0.8313
LOG(A)	1.474492	0.690364	2.135818	0.0523
LOG(R)	-0.111364	0.410608	-0.271217	0.7905
LOG(T)	0.276000	2.758548	0.100053	0.9218
LOG(W)	-2.448158	1.354245	-1.807766	0.0938
LOG(SW)	-0.140111	1.208660	-0.115922	0.9095
LOG(PRE)	-0.163492	0.241221	-0.677769	0.5098
R-squared	0.394401	Mean dependent var	13.59410	
Adjusted R-squared	0.114894	S.D. dependent var	0.183680	
S.E. of regression	0.172806	Akaike info criterion	-0.404080	
Sum squared resid	0.388204	Schwarz criterion	-0.055574	
Log likelihood	11.04080	Hannan-Quinn criter.	-0.336048	
F-statistic	1.411061	Durbin-Watson stat	1.806797	
Prob(F-statistic)	0.282355			

Variance Inflation Factors			
Date: 01/17/24 Time: 23:06			
Sample: 2002 2021			
Included observations: 20			
Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	168.6081	112925.5	NA
LOG(A)	0.476603	49150.51	1.460939
LOG(R)	0.168599	2926.395	6.782652
LOG(T)	7.609587	64454.54	4.496334
LOG(W)	1.833980	912.9393	3.035996
LOG(SW)	1.460859	163.4166	10.65074
LOG(PRE)	0.058188	91.13488	5.089389

Figure: R-squared and VIF values

Kurnool District Results

Dependent Variable: LOG(P)
 Method: Least Squares
 Date: 01/18/24 Time: 23:38
 Sample: 2002 2021
 Included observations: 20

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.662368	9.636018	0.898957	0.3850
LOG(A)	1.173548	0.156793	7.484711	0.0000
LOG(R)	0.124920	0.245629	0.508574	0.6196
LOG(T)	-3.123778	2.415258	-1.293352	0.2184
LOG(W)	0.388035	0.958806	0.404706	0.6923
LOG(PRE)	0.042394	0.142151	0.298229	0.7702
LOG(SW)	-1.557524	1.159453	-1.343327	0.2021

R-squared	0.904841	Mean dependent var	12.43248
Adjusted R-squared	0.860922	S.D. dependent var	0.379512
S.E. of regression	0.141532	Akaike info criterion	-0.803365
Sum squared resid	0.260407	Schwarz criterion	-0.454858
Log likelihood	15.03365	Hannan-Quinn criter.	-0.735333
F-statistic	20.60228	Durbin-Watson stat	1.373455
Prob(F-statistic)	0.000006		

Variance Inflation Factors
 Date: 01/18/24 Time: 23:39
 Sample: 2002 2021
 Included observations: 20

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	92.85284	92707.72	NA
LOG(A)	0.024584	3093.911	1.859876
LOG(R)	0.060333	1271.273	3.804000
LOG(T)	5.833470	73303.20	8.058292
LOG(W)	0.919309	1143.248	4.099504
LOG(PRE)	0.020207	26.88663	4.286701
LOG(SW)	1.344331	236.1210	16.69431

Figure: R-squared and VIF values

Chittoor District Results

Dependent Variable: LOG(P)
 Method: Least Squares
 Date: 01/18/24 Time: 23:17
 Sample: 2002 2021
 Included observations: 20

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-10.99073	16.09622	-0.682815	0.5067
LOG(A)	1.010818	0.174566	5.790472	0.0001
LOG(R)	0.366685	0.336016	1.091272	0.2950
LOG(T)	3.357556	4.189516	0.801418	0.4373
LOG(W)	-1.330524	0.873464	-1.523272	0.1516
LOG(PRE)	-0.310270	0.303003	-1.023981	0.3245
LOG(SW)	0.425970	1.710815	0.248986	0.8073
R-squared	0.804776	Mean dependent var	10.86459	
Adjusted R-squared	0.714672	S.D. dependent var	0.349542	
S.E. of regression	0.186712	Akaike info criterion	-0.249286	
Sum squared resid	0.453196	Schwarz criterion	0.099221	
Log likelihood	9.492857	Hannan-Quinn criter.	-0.181254	
F-statistic	8.931688	Durbin-Watson stat	0.926573	
Prob(F-statistic)	0.000539			

Variance Inflation Factors

Date: 01/18/24 Time: 23:18
 Sample: 2002 2021
 Included observations: 20

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	259.0882	148639.7	NA
LOG(A)	0.030473	1666.821	1.647557
LOG(R)	0.112907	1527.348	6.108903
LOG(T)	17.55205	128489.2	8.939259
LOG(W)	0.762940	330.4051	2.020294
LOG(PRE)	0.091811	114.5692	4.917743
LOG(SW)	2.926887	308.4354	9.301188

Figure: R-squared and VIF values

Vizianagaram District Results

Dependent Variable: LOG(P)
 Method: Least Squares
 Date: 01/17/24 Time: 23:03
 Sample: 2002 2021
 Included observations: 20

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-25.93564	17.02383	-1.523490	0.1516
LOG(A)	3.149110	0.935626	3.365778	0.0051
LOG(R)	-0.049961	0.312638	-0.159805	0.8755
LOG(T)	0.386654	2.687692	0.143861	0.8878
LOG(W)	0.050621	0.905092	0.055929	0.9562
LOG(SW)	-0.064435	1.210503	-0.053230	0.9584
LOG(PRE)	0.330772	0.375488	0.880914	0.3944

R-squared	0.847480	Mean dependent var	12.55056
Adjusted R-squared	0.777086	S.D. dependent var	0.323062
S.E. of regression	0.152529	Akaike info criterion	-0.653701
Sum squared resid	0.302448	Schwarz criterion	-0.305195
Log likelihood	13.53701	Hannan-Quinn criter.	-0.585669
F-statistic	12.03913	Durbin-Watson stat	1.948030
Prob(F-statistic)	0.000118		

Variance Inflation Factors
 Date: 01/17/24 Time: 23:06
 Sample: 2002 2021
 Included observations: 20

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	289.8109	249136.5	NA
LOG(A)	0.875396	102428.0	6.277329
LOG(R)	0.097742	2205.985	2.892472
LOG(T)	7.223689	74722.49	3.550452
LOG(W)	0.819191	520.5281	2.305991
LOG(SW)	1.465318	207.4334	16.78579
LOG(PRE)	0.140991	403.3877	12.63521

Figure: R-squared and VIF values

Final Regression Model

- $\text{Log}(P) = C + \beta_1 \log(A) + \beta_2 \log(R) + \beta_3 \log(T) + \beta_4 \log(W) + \beta_5 \log(\text{pre}) + \mu$

where,

- C is the constant term
- μ is the error term
- $\beta_1 \beta_2 \beta_3 \beta_4 \beta_5$ are the regression coefficients
- P = production of rice
- A = area under cultivation of rice
- R = average rainfall over six months (Kharif)
- T = average temperature
- W = Wind speed
- pre = Precipitation

West Godavari District Results

Dependent Variable: LOG(P)
 Method: Least Squares
 Date: 01/11/24 Time: 06:35
 Sample: 2002 2021
 Included observations: 20

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	27.59942	15.53708	1.776358	0.0974
LOG(A)	0.019347	0.869063	0.022262	0.9826
LOG(R)	-0.556050	0.304831	-1.824128	0.0895
LOG(T)	-2.984660	2.221395	-1.343597	0.2005
LOG(W)	-1.147709	0.928538	-1.236039	0.2368
LOG(PRE)	-0.105453	0.289000	-0.364888	0.7206

R-squared	0.508443	Mean dependent var	13.44971
Adjusted R-squared	0.332887	S.D. dependent var	0.192377
S.E. of regression	0.157128	Akaike info criterion	-0.620187
Sum squared resid	0.345649	Schwarz criterion	-0.321467
Log likelihood	12.20187	Hannan-Quinn criter.	-0.561874
F-statistic	2.896189	Durbin-Watson stat	1.631471
Prob(F-statistic)	0.053295		

Variance Inflation Factors
 Date: 01/17/24 Time: 22:45
 Sample: 2002 2021
 Included observations: 20

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	241.4008	195551.6	NA
LOG(A)	0.755271	93578.28	1.881390
LOG(R)	0.092922	1973.782	4.780050
LOG(T)	4.934595	49578.36	3.356702
LOG(W)	0.862183	393.2900	1.659501
LOG(PRE)	0.083521	191.8663	6.070217

Figure: R-squared and VIF values

Krishna District Results

Dependent Variable: LOG(P)
 Method: Least Squares
 Date: 01/11/24 Time: 06:34
 Sample: 2002 2021
 Included observations: 20

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-3.203703	12.11165	-0.264514	0.7952
LOG(A)	1.458100	0.651483	2.238123	0.0420
LOG(R)	-0.142794	0.297298	-0.480307	0.6384
LOG(T)	0.473532	2.091492	0.226409	0.8242
LOG(W)	-2.346904	0.997777	-2.352133	0.0338
LOG(PRE)	-0.156852	0.225914	-0.694298	0.4989

R-squared	0.393775	Mean dependent var	13.59410
Adjusted R-squared	0.177267	S.D. dependent var	0.183680
S.E. of regression	0.166606	Akaike info criterion	-0.503047
Sum squared resid	0.388605	Schwarz criterion	-0.204327
Log likelihood	11.03047	Hannan-Quinn criter.	-0.444733
F-statistic	1.818751	Durbin-Watson stat	1.776755
Prob(F-statistic)	0.173663		

Variance Inflation Factors
 Date: 01/17/24 Time: 22:46
 Sample: 2002 2021
 Included observations: 20

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	146.6921	105695.4	NA
LOG(A)	0.424431	47088.42	1.399646
LOG(R)	0.088386	1650.435	3.825296
LOG(T)	4.374338	39860.31	2.780647
LOG(W)	0.995558	533.1506	1.773002
LOG(PRE)	0.051037	85.99573	4.802396

Figure: R-squared and VIF values

Kurnool District Results

Dependent Variable: LOG(P)
 Method: Least Squares
 Date: 01/17/24 Time: 22:12
 Sample: 2002 2021
 Included observations: 20

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.783782	8.828229	0.315327	0.7572
LOG(A)	1.191281	0.160662	7.414812	0.0000
LOG(R)	-0.030667	0.222744	-0.137678	0.8925
LOG(T)	-1.292705	2.050345	-0.630482	0.5385
LOG(W)	0.955138	0.885254	1.078941	0.2989
LOG(PRE)	-0.056246	0.125166	-0.449372	0.6600

R-squared	0.891632	Mean dependent var	12.43248
Adjusted R-squared	0.852929	S.D. dependent var	0.379512
S.E. of regression	0.145542	Akaike info criterion	-0.773381
Sum squared resid	0.296554	Schwarz criterion	-0.474661
Log likelihood	13.73381	Hannan-Quinn criter.	-0.715068
F-statistic	23.03793	Durbin-Watson stat	1.433655
Prob(F-statistic)	0.000003		

Variance Inflation Factors
 Date: 01/17/24 Time: 22:43
 Sample: 2002 2021
 Included observations: 20

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	77.93762	73587.04	NA
LOG(A)	0.025812	3071.979	1.846691
LOG(R)	0.049615	988.6126	2.958202
LOG(T)	4.203915	49955.51	5.491658
LOG(W)	0.783675	921.6131	3.304756
LOG(PRE)	0.015666	19.71242	3.142872

Figure: R-squared and VIF values

Chittoor District Results

Dependent Variable: LOG(P)
 Method: Least Squares
 Date: 01/18/24 Time: 22:48
 Sample: 2002 2021
 Included observations: 20

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-7.815116	9.484669	-0.823974	0.4238
LOG(A)	0.991945	0.151890	6.530666	0.0000
LOG(R)	0.371885	0.323937	1.148017	0.2702
LOG(T)	2.484405	2.214096	1.122085	0.2807
LOG(W)	-1.423455	0.762791	-1.866115	0.0831
LOG(PRE)	-0.308212	0.292568	-1.053471	0.3100

R-squared	0.803845	Mean dependent var	10.86459
Adjusted R-squared	0.733789	S.D. dependent var	0.349542
S.E. of regression	0.180348	Akaike info criterion	-0.344528
Sum squared resid	0.455357	Schwarz criterion	-0.045809
Log likelihood	9.445282	Hannan-Quinn criter.	-0.286215
F-statistic	11.47442	Durbin-Watson stat	0.941712
Prob(F-statistic)	0.000150		

Variance Inflation Factors
 Date: 01/18/24 Time: 22:57
 Sample: 2002 2021
 Included observations: 20

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	89.95894	55315.92	NA
LOG(A)	0.023071	1352.538	1.336906
LOG(R)	0.104935	1521.448	6.085303
LOG(T)	4.902223	38463.63	2.675995
LOG(W)	0.581849	270.0759	1.651405
LOG(PRE)	0.085596	114.4840	4.914084

Figure: R-squared and VIF values

Vizianagaram District Results

Dependent Variable: LOG(P)
 Method: Least Squares
 Date: 01/13/24 Time: 07:09
 Sample: 2002 2021
 Included observations: 20

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-25.55942	14.92561	-1.712454	0.1089
LOG(A)	3.114918	0.655611	4.751170	0.0003
LOG(R)	-0.049324	0.301077	-0.163825	0.8722
LOG(T)	0.404790	2.569312	0.157548	0.8771
LOG(W)	0.066628	0.822714	0.080985	0.9366
LOG(PRE)	0.312864	0.160692	1.946972	0.0719

R-squared	0.847447	Mean dependent var	12.55056
Adjusted R-squared	0.792964	S.D. dependent var	0.323062
S.E. of regression	0.146997	Akaike info criterion	-0.753483
Sum squared resid	0.302514	Schwarz criterion	-0.454763
Log likelihood	13.53483	Hannan-Quinn criter.	-0.695170
F-statistic	15.55427	Durbin-Watson stat	1.943892
Prob(F-statistic)	0.000028		

Variance Inflation Factors
 Date: 01/17/24 Time: 22:48
 Sample: 2002 2021
 Included observations: 20

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	222.7738	206194.4	NA
LOG(A)	0.429825	54149.74	3.318581
LOG(R)	0.090647	2202.750	2.888230
LOG(T)	6.601367	73521.80	3.493402
LOG(W)	0.676858	463.0700	2.051446
LOG(PRE)	0.025822	79.54493	2.491567

Figure: R-squared and VIF values

- **Krishna zone**

$$\text{Log}(P) = -3.20 + 1.458 \log(A) - 0.142 \log(R) + 0.473 \log(T) - 2.346 \log(W) - 0.156 \log(\text{pre}) + \mu$$

- **Kurnool zone**

$$\text{Log}(P) = 2.783 + 1.91 \log(A) - 0.03 \log(R) - 1.292 \log(T) + 0.955 \log(W) - 0.056 \log(\text{pre}) + \mu$$

- **Chittoor zone**

$$\text{Log}(P) = -7.815 + 0.991 \log(A) + 0.371 \log(R) + 2.484 \log(T) - 1.423 \log(W) - 0.308 \log(\text{pre}) + \mu$$

- **Vizianagaram zone**

$$\text{Log}(P) = -25.559 + 3.114 \log(A) - 0.049 \log(R) + 0.404 \log(T) + 0.066 \log(W) + 0.312 \log(\text{pre}) + \mu$$

- **West Godavari zone**

$$\text{Log}(P) = 27.599 + 0.019 \log(A) - 0.556 \log(R) - 2.984 \log(T) - 1.147 \log(W) - 0.105 \log(\text{pre}) + \mu$$

Most Significant variables for different zones

District - Variable(s)

- Krishna (Krishna zone) - Area and Wind
- Kurnool (Scarce rainfall zone) - Area
- Chittoor (Southern zone) - Area and Wind
- Vizianagaram (North coastal zone) - Area and Precipitation
- West Godavari (Godavari zone) - Rain

Krishna zone

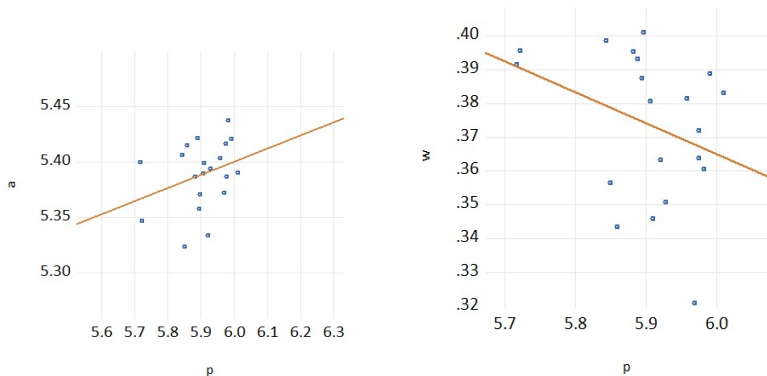


Figure: Production with respect to Area and Wind

Kurnool zone

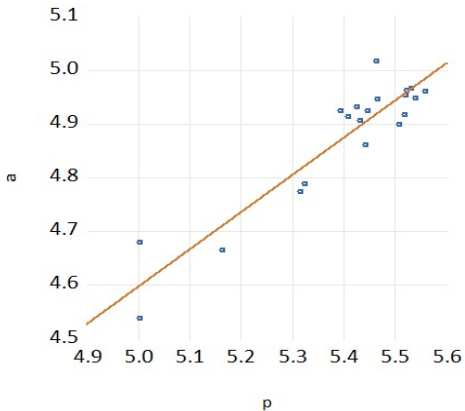


Figure: Production with respect to Area

Chittoor zone

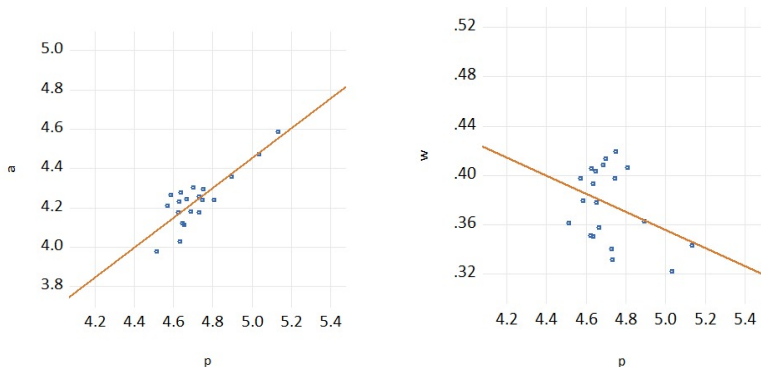


Figure: Production with respect to Area and Wind

Vizianagaram zone

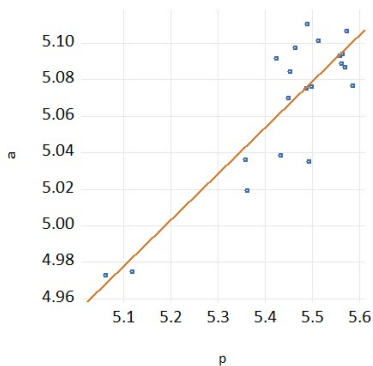
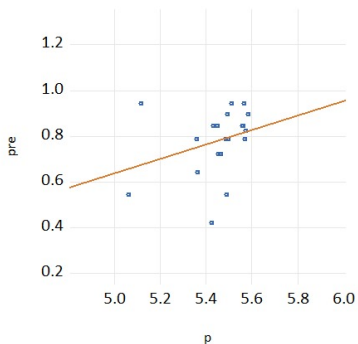


Figure: Production with respect to Area and precipitation

West Godavari zone

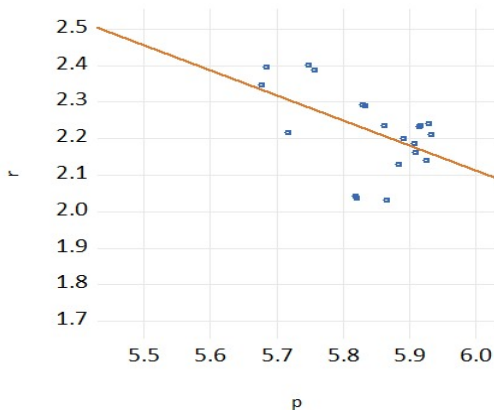


Figure: Production with respect to Rain

Test results

District	Breusch-Pagan-Godfrey	Jarque-Bera (normality) test	Residuals normality distribution
Krishna (Krishna zone)	0.4529	0.72	0.724
Kurnool (scarce rainfall zone)	0.1549	0.50	0.861
Chittoor (southern zone)	0.8737	0.7	0.584
Vizianagaram (north coastal zone)	0.1612	0.84	0.860
West Godavari (Godavari zone)	0.0975	0.84	0.847

Conclusion

- The **area under cultivation** is the most important explanatory variable, affecting four out of five zones significantly.
- **Wind** is the second most important factor determining productivity in the **Krishna and Southern** zone after area.
- Godavari zone is prominently affected by **rainfall**.
- Surprisingly, every district is receiving **adequate temperatures** which are in the **desired** range for **efficient** growth of rice crops.

- Individual equations for each zone can result in improved regression.
- From the results, it is clear that **production is not solely dependent** on considered variables and there are still a lot of variables that need to be taken into account such as:
 - **Irrigation facility**
 - **Soil erosion**
 - **Pesticides and Manures**
 - **Capital**
 - **Labour etc..**

- Padakandla, Steven Raj. "Climate sensitivity of rice yields: an agro climatic zone analysis in the undivided state of Andhra Pradesh, India." *Journal of Public Affairs* 21.3 (2021): e2261.
- Mundfrom, Daniel J., et al. "Multiple Linear Regression Viewpoints." (2006): 1-6.
- Mukherjee, Asis, and A. K. S. Huda. "Assessment of climate variability and trend on wheat productivity in West Bengal, India: crop growth simulation approach." *Climatic change* 147.1-2 (2018): 235-252.
- Sellam, V., and E. Poovammal. "Prediction of crop yield using regression analysis." *Indian Journal of Science and Technology* 9.38 (2016): 1-5.

THANK YOU