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Prediction of gross cropped area in Madhya Pradesh through a multiple regression approach

Chetan Patel and KS Kushwaha

Abstract
Indian agriculture is a land-based activity and as such water and land have been the basic elements of life support system and is an important resource for the economic life of a majority of people in the country. The pattern of land use is not uniform but it changes from place to place and time to time. The gross cropped area (Y), forest area (X_1), area not available for cultivation (X_2), area for other uncultivable land (X_3), and area of fallow land (X_4), are varying from year to year in Madhya Pradesh.
The multiple Regression model may describe the pattern and projection of total cropped area based on predictor variables (x_1, x_2, x_3, x_4). In order to get evidence about the applicability of multiple regression procedure, Jarqua-Bera (J.B.) test, histogram of residuals, normal probability plot to test normality of errors, spearman's rank correlation test for homogeneity of errors and Durbin-Watson 'd' statistic to test the independence of autocorrelation in error terms have been applied on secondary data of variables (y, x_1, x_2, x_3, and x_4) in M.P. state for 31 years.

Keywords: Autocorrelation, normality of error, homogeneity of residuals, multiple regression procedure, heteroscedasticity

Introduction

Land use is an important natural resource which embraces the elements like overlying temperature, moisture, topography, soil matrix and physical structure. It is certainly a manifestation of past and present human activities. Therefore land use pattern is directly concerned with the problem arising in the process of deciding upon and carrying out into action for the optimum use.
The pattern of land use is not uniform but it changes from place to place and time to time. The land use pattern is useful to prepare integrated plans for optimal utilization of natural resources, their planning for development of the state or nation.
The gross cropped area (Y), forest area(X_1), area not available for cultivation(X_2), area for other uncultivable land(X_3), and area of fallow land(X_4), are varying from year to year in Madhya Pradesh. The present study is undertaken to investigate the pattern of changing the areas related to variables (y, x_1, x_2, x_3, and x_4) in the State. The gross cropped area(y) is to be projected for the coming years.he mulltiple regression model Should follows some basic assumption like (1) Normality of errors (2) Homogeneity of errors variance and (3) Independence of serial correlation (no autocorrelation). Thus in our study we test all these assumption. Normality of error will be tested through histogram of residual, normal probability plot and Jarqua-Bera (JB) test and the homogeneity of errors will be tested through Spearman's Rank Correlation Test.
To test independence of serial correlations in error terms, the most celebrated test for detecting serial correlation has been developed by statisticians Durbin and Watson (1951) [5]. It̀s popularity known as the "Durbin- Watson d statistics".
The following objectives have been considerd for study in this investigation:

1. To fit the multiple regression model of response variable Y on predictor variables (x_1, x_2, x_3 and x_4)
2. To test the normality and homogeneity of error variances in the fitted model
3. To test the independence of 'autocorrelation' (serial correlation) in the model

The studies of general land use and agricultural land use / land cover and their changes have been made by many researchers in different parts of the world. Rai, (1981) [12] analyzed the hill slope element like crest, scrap, debris and pediment and its impact on land use around Sagar, Madhya Pradesh and came to the conclusion that different methods of soil conservations help for planning of land use. Dagade, (1985) [3] highlighted the changes in general land use and agricultural land use pattern in Panchganga basin. Chaugule, (1987) [2] studied the geology, landforms and land use pattern of Varana basin and suggested a spatial model for the study area. Datta, (1988) [4] studied the general pattern of land use of the Bino basin, its utilization and changes with considering the physical and cultural factors. He concluded that altitude plays a very dynamic role for influencing the land use in the Himalayan region. Gopalkrishnan, *et al*. (1996) [6] carried out the study of soil physiography relationship in Kodayar River basin of Kanyakumari District for the proper management and planning of land use. They concluded that the detail study of soil is essential for optimum utilization of the agricultural potentialities and planning of land use in the area. Jha, Mrityunjay Mohan (1999) has carried out a comprehensive project work entitled "Application of GIS and RS in the study of "Population growth and its impact on land use in part of Western Doon Valley". He employed the ERDAS Imagine, ILWIS and Arcinfo GIS softwares to find out the changes in land use and land cover. He came to the conclusion that vegetation exploitation, population growth, farming activities is the major causes of reduction in land use and land cover. Rajan, *et al*. (2001) [13] employed a GIS based integrated land use and land cover change model to study the changes in agricultural and urban land use. Mohamed (2003) [11] conducted a research on "Urban rural land use change detection and analysis using GIS and Remote Sensing technologies" to investigate the effects of urbanization on agricultural lands of Baharin. Singh, *et al*. (2004) [14] studied the fluvial and denudational landforms, their occurance, lithology, hydro-geomorphology, ground water quality. Karwariya and Goyal (2011) [9] studied land use is a product of interactions between cultural backgrounds, state and physical needs of the society with natural potential of land. Bhupal (2012) [1] increased in land prices due to enhanced income of some sections, future need of prime land and returns from other than agricultural uses seem to be the driving force for change in land use.

Data and Methodology

Study area

The present study is confined to the Madhya Pradesh state which is the center region of India. It is sub-tropical area in nature of climatic condition.

Data collection

Secondary data of gross cropped area (Y), forest area (x_1), area under not cultivation (x_2), other uncultivable land (x_3) and fallow land (x_4) in M.P. for 31 years starting from 1983-84 to 2013-14 have been considered and were collected with the Collaboration of Agro-Economic Research Centre, J.N.K.V.V. Jabalpur (M.P.) and with other sources.

Methodology

The collected data were compiled and were analyzed in the view of objective stated earlier. For analysis of the data the statistical techniques adopted to analyze the data are discussed in the following heads.

Multiple regression

The fitted multiple regression model had been postulated as

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + \beta_4 x_{4i} + \epsilon_i \qquad \text{.... (1)}$$

Where;

Where β_0 is the intercept, β_j are partial unknown parameters to be estimated (where j =1, 2,….,4) and ϵ_i is the error term as $\epsilon_i \sim N(0, \sigma_e^2)$ and (i = 1, 2,.….n) where n is the number of years considered in the study. Using least square technique, the fitted multiple regression line will be obtained as

$$\hat{y}_i = b_0 + b_1 x_{1i} + b_2 x_{2i} + b_3 x_{3i} + b_4 x_{4i} \qquad \text{.... (2)}$$

Where;

the "b_0" is called intercept term is the sample mean $\bar{y}_i = \frac{1}{n}\sum_{i=1}^{n} y_i$, n is the sample size.

The b_j are called partial regression coefficients (where j =1, 2,…., 4)

Then estimate of y_i will be obtained as:

$$\hat{y}_i = \bar{y}_i + b_1 x_{1i} + b_2 x_{2i} + b_3 x_{3i} + b_4 x_{4i} \qquad \text{.... (3)}$$

The Multiple Correlation Coefficient (R) was computed as

$$R = \frac{cov(y_i, \hat{y}_i)}{\sqrt{v(y_i), v(\hat{y}_i)}} \qquad \text{.... (4)}$$

For testing the significance of R, the test statics F is computed as

$$F_{(k,n-k-1)} = \frac{R^2(n-k-1)}{(1-R^2)k} \qquad \text{.... (5)}$$

Where k is the number of explanatory variables has been considered in this study.

The statistical significance of partial regression coefficients was tested using student's 't' statistic which is defined as:-

$$t_{n-2} = \frac{\left|b_{yx_j}\right|\sqrt{(n-2)\sum_i^n (x_{ij}-\bar{x}_{nj})^2}}{\sqrt{\sum_i^n (y_i-\bar{y}_n)^2 - b_{yx_j}^2 \sum_i^n (x_{ij}-\bar{x}_{nj})^2}} \qquad \text{.... (6)}$$

Jarqua-Bera (JB) test for Normality of errors:

The Jarqua-Bera test depends on skewness and kurtosis statistics. The JB test statistic written as:

$$JB = n\left[\frac{s^2}{6} + \frac{(k-3)^2}{24}\right] \qquad \text{.... (7)}$$

Where (s, k) are respectively the skewness and kurtosis of errors $e_i = (y_i - \hat{y}_i)$. The J.B. statistic approximately follows chi square. If the J.B. statistic is equal to zero, it means that the distribution has s = 0 and k = 3 and the errors(e_i) is distributed as (0, σ_e^2).

Histogram of residual

The histogram of residuals in a simple graphic device to know something about the shape of probability density function of a random variable (e_i). On the horizontal axis(x), the value of residuals (e_i) were taken into suitable intervals, and frequencies of e_i on y axis to erect the histogram. Then the superimposition of bell-shaped normal distribution curve was drawn on the histogram, to have a idea as to whether normal approximation might be appropriate or not.

Normal probability plot

Let a normal probability plot of observed cumulative probabilities of occurrence of the standardized residuals on Y axis and its expected normal probabilities of occurrence on X axis, be drawn and if a 45-degree straight line would appear then it conforms that the normality assumption of error is followed.

Spearman's Rank correlation test of heteroscedasticity in errors

Spearman's rank correlation coefficient r_s is defined as:

$$r_s = 1\text{-}6\left[\frac{\sum di^2}{(n^2-1)}\right] \quad \text{…. (8)}$$

Where;

d_i in the Difference of ranks assigned to two different attributes of i_{th} individual or phenomenon and n is the number of paired ranked. We proceed as followed.

We obtain the residuals ei = $(y_i - \hat{y}_i)$ from the fitted regression line. Then ignoring the signs of e_i's, we allot the ranks to both $|e_i|$ and (y_i) according to ascending or descending order of magnitudes. There is computed from equation (8) assuming the small hypothesis H_o: the population rank correlation coefficient ρ_s was zero, we act 't' statistic to test follows as:

$$t = \frac{r_s\sqrt{n-2}}{\sqrt{1-{r_s}^2}} \quad \text{…. (9)}$$

If computed value of exceeds the table value $t_{(0.05,n-2)}$ then Ho in significant otherwise, it is on significant. If the regression model involves more than one X variable, r_s in computed between $|e_i|$ and $\hat{y}_i$ for each of the X variables separately and tested according to test statistic 't' reported in equation (9)

Durbin-Watson 'd' statistics to test the independence of autocorrelation in error:

The researchers must take precautions in drawing inferences about the nature of autocorrelation in the errors.

Durbin- Watson (1951) [5] proposed a widely used test statistic to test the independence of autocorrelation (ρ_e) known as "Durbin-Watson" 'd' statistic. The 'd' statistic following Kushwaha and kumar (2009) [10], the 'd' statistic for one tail test is defined as:

$$d = \frac{\sum_{i=2}^{n}(e_i - e_{i-1})^2}{\sum_{i=1}^{n} e_i^2} \quad \text{…. (10)}$$

To test the null hypothesis stated as-

H_o: The errors e_i's in regression equation are not auto correlated i.e ρ = 0

With $H_1 : \rho > 0$

The value of "d" becomes smaller as the estimated errors ei,s increase. The lower and upper critical values (d_L, d_U) are tabulated for different value of (k, n). Where k is the number of predictor variables involved in the model. The statistical inference are teken as –

If $d < d_L$, H_0: ρ= 0 rejected

If $d > d_U$, H_0: ρ = 0, is accepted

If $d_L < d < d_U$, decision is inconclusive at $\propto_{\%}$ level of significance.

Result and Discussions

Test for significance of partial Regression Coefficients. b_{yx_j} $(j = 1,2,3,4)$:

In this section, the values of sample regression coefficients b_{yx_j} and their standard errors were worked out and are provided in table 1.

Table 1: The values of b_{yx_j}, S.E. (b_{yx_j}) and 't' statistic.

Regression coefficients b_{yx_j}	Values of b_{yx_j}	S.E. (b_{yx_j})	Calculated t values	Critical values
b_{yx_1}	1.156	0.176	6.581	0.000
b_{yx_2}	1.369	1.229	1.115	0.275
b_{yx_3}	-0.999	0.803	1.245	0.224
b_{yx_4}	-6.083	0.982	-6.196	0.000

The table 1 reveals that the partial regression coefficients b_{yx_j} $(j = 1,2,3,4)$ are found significant. Hence, we consider all the four predictor variables (X_1, X_2, X_3, X_4) to get the best fitted regression line of y on (x_j, j=1,2,3,4).The fitted multiple regression line has been obtained as

$$y_i = 15531.765 + 1.156\, x_{1i} + 1.369\, x_{2i} - 0.999x_{3i} -6.083x_{4i} \quad \text{…. (11)}$$

The value of coefficient of multiple determination (R^2) obtained as R^2 = 0.90

The value of F statistic for observed multiple correlation (R) is obtained as $F_{(4,26)}$ = 5708 with tabulated $F_{0.05(4.26)}$ = 2.74 which gives an evidence for null hypothesis h_0:R =0.0 to significant at ∝=0.05 level of significance. Hence, one

Remark

The table 1 reveals that the predictor variable (X_3,& X_4,) are negatively correlated with gross cropped areas y. The values ($\hat{y}_i$, x_3, x_4) in table 2, reveals that with the decrease in the value of (X_3,& X_4,) both can conclude regression written in (11) is the best fitted regression equation. The value R^2=0.90 indicator that 90% of variation present in gross cropped area (y) can be explain by the fitted regression in (11).

Jarqua- bera (j b) test for normally of error

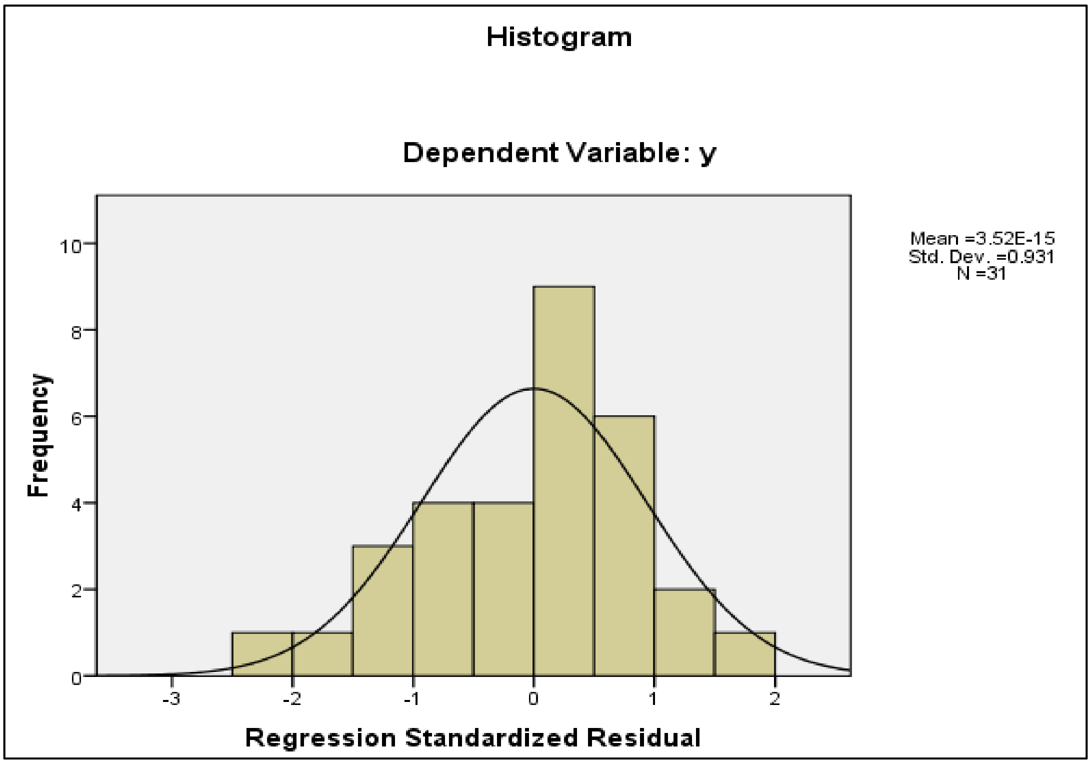
The value of skewness and kurtosis is of errors are obtained from the fitted model in (11) and are provided in the table given below.

Table 2: values of $\hat{y}_i$ and S,E, (e_i's):

Year	gross cropped area (y)	forest area (x_1)	area not available for cultivation (x_2)	other uncultivable land (x_3)	fallow land (x_4)	Expected Yi	Error
1983-84	22350.2	14028.5	4561.5	4679.7	1687.4	23059.45922	709.2592165
1984-85	22406.7	14050.7	4568.5	4683.8	1702.0	23001.80334	595.1033364
1985-86	23015.9	14029.0	4557.0	4638.2	1573.5	23788.23108	772.3310797
1986-87	22213.6	14003.1	4603.1	4614.5	1887.9	21932.50385	-281.096154
1987-88	22693.8	14026.5	4579.4	4584.5	1714.8	23010.10401	316.3040082
1988-89	22707.9	14063.1	4548.7	4546.6	1744.8	22865.75885	157.858855
1989-90	22449.2	14105.1	4545.1	4496.8	1849.0	22325.27908	-123.9209172
1990-91	23880.3	14325.7	4458.0	4413.0	1587.9	24133.18435	252.8843526
1991-92	23089.4	14369.1	4423.2	4383.2	1803.1	22856.36756	-233.0324432
1992-93	23807	14405.0	4416.0	4312.0	1667.0	23787.10407	-19.89592777
1993-94	24829	14645.0	4214.0	4218.0	1531.0	24709.27095	-119.7290487
1994-95	24689	14659.0	4217.0	4196.0	1614.0	24246.63793	-442.3620677
1995-96	25040	14670.0	4232.0	4165.0	1528.0	24834.0389	-205.9611024
1996-97	25451	14715.0	4213.0	4133.0	1492.0	25111.03125	-339.968749
1997-98	25955.1	14711.9	4228.9	4097.0	1482.4	25223.57896	-731.5210429
1998-99	20482	8492	3192	1716	1040	21681.61547	1199.615475
1999-00	20419	8613.0	3200.0	1673.0	1024.0	21972.79118	1553.791181
2000-01	17870.415	8655.004	3237.341	2805.563	1393.939	18690.34689	819.9318924
2001-02	19043.756	8682.798	3255.409	2717.675	1240.606	19767.82059	724.0645927
2002-03	18078.221	8680.951	3307.325	2627.373	1622.356	17604.71322	-473.5077775
2003-04	19788.168	8683.14	3350.413	2556.882	1219.886	20185.03099	396.8629901
2004-05	20202.639	8688.481	3364.098	2536.245	1191.862	20401.04697	198.4079749
2005-06	19607.592	8691.548	3388.579	2519.323	1185.336	20494.7265	887.1345008
2006-07	20113.059	8698.529	3397.273	2543.76	1380.829	19301.04427	-812.0147298
2007-08	20416.071	8702.552	3391.789	2540.75	1433.49	18980.84178	-1435.229218
2008-09	20656.767	8695.933	3400.895	2516.108	1202.359	20416.31926	-240.4477372
2009-10	21411.401	8688.874	3431.507	2508.423	1155.374	20743.57931	-667.8216883
2010-11	22045.593	8697.03	3423.872	2444.323	1071.525	21316.68494	-728.9080642
2011-12	22516.389	8690.636	3460.175	2410.401	958.255	22081.9556	-434.4334025
2012-13	23129.786	8692.762	3513.236	2330.72	867.445	22789.12025	-340.6657548
2013-14	24047.027	8690.816	3507.275	2318.537	817.618	23093.99315	-953.0338514
Total	684405.984					684405.9838	-0.000222168

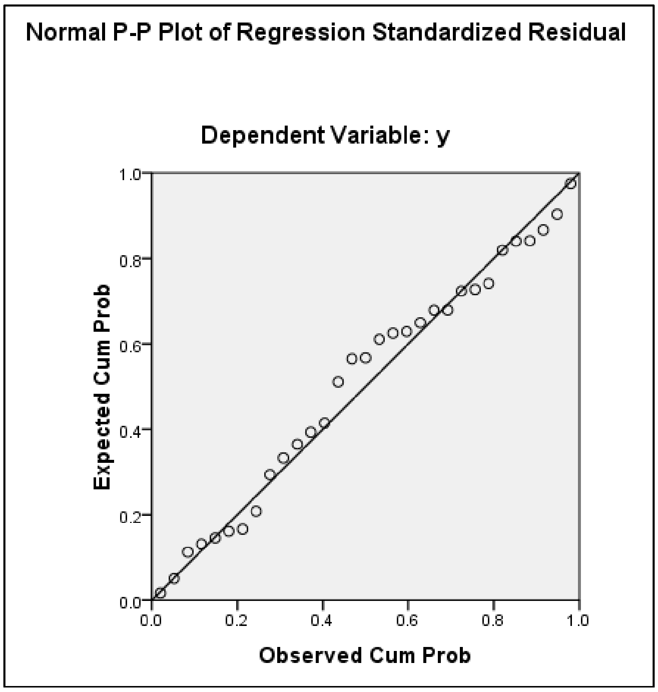
Skewness s = 0.27 and kurtosis k = -0.21 substituting the values of (s. k) in (7) the value of J.B. statistic in obtained as JB = 12.17 > 0.0 which reveals that error b not normally distributed. If happens due to (n=3<50) i.e. not following the asymptotic property of chi square distribution.

Histogram of Residuals



Graph 1: Histogram of residuals in gross cropped area the graph 1 reveals that the be shaped normal distribution curve drawn on histogram given the shape of normal distribution with approximate mean equal to zero and standard deviation ‘e=0.931.

Normal Probability Plot



Graph 2: Normal Probability Plot in gross cropped area.

The graph of NPP between observed cum Probability and estimated cum Probability in approximate a straight time which reveal that the residuals are normally distributed in fitted regression model with mean approximation equal to zero and standard deviation ‘e = 0.931.

Spearman’s Rank Correlation Test for Normality of Errors

Table 3: Error (e_i), Rank (x_1) and Rank (e_i), with Forrest Area (x_1)

year	Forest area(x_1)	Error (e)	rank x_1	Rank (e)	d_i	d_i^2
1983-84	14028.5	709.2592	5	21	16	256
1984-85	14050.7	595.1033	7	19	12	144
1985-86	14029.0	772.3311	6	25	19	361
1986-87	14003.1	281.096	3	11	8	64
1987-88	14026.5	316.304	4	12	8	64
1988-89	14063.1	157.8589	8	5	-3	9
1989-90	14105.1	123.921	9	4	-5	25
1990-91	14325.7	252.8844	10	10	0	0
1991-92	14369.1	233.032	11	8	-3	9
1992-93	14405.0	19.8959	12	2	-10	100
1993-94	14645.0	119.729	13	3	-10	100
1994-95	14659.0	442.362	14	17	3	9
1995-96	14670.0	205.961	15	7	-8	64
1996-97	14715.0	339.969	17	13	-4	16
1997-98	14711.9	731.521	16	24	8	64
1998-99	8492	1199.615	1	30	29	841
1999-00	8613.0	1553.791	2	32	30	900
2000-01	17870.4	819.9319	18	27	9	81
2001-02	19043.8	724.0646	20	22	2	4
2002-03	18078.2	473.508	19	18	-1	1
2003-04	19788.2	396.863	22	15	-7	49
2004-05	20202.6	198.408	24	6	-18	324
2005-06	19607.6	887.1345	21	28	7	49
2006-07	20113.1	812.015	23	26	3	9
2007-08	20416.1	1435.23	25	31	6	36
2008-09	20656.8	240.448	26	9	-17	289
2009-10	21411.4	667.822	27	20	-7	49
2010-11	22045.6	728.908	28	23	-5	25
2011-12	22516.4	434.433	29	16	-13	169
2012-13	23129.8	340.666	30	14	-16	256
2013-14	24047	953.034	31	29	-2	4
Total		0.00022	496	527	31	4371

Spearman's Rank Correlation coefficient r_s = 0.13. Calculated value of 't' statistic $|t|$ = 0.707 and critical $t_{(0.05,29)}$ = 2.05 which reveals that we may accept the hypothesis of homogeneity in errors.
Similarly, we work out the values of rank correlation coefficient for the areas (x_2, x_3, x_4) as r_s = (-0.50,-0.47,-0.52) respectively. The calculated values of t Statistic were obtained as /t/=(3.12, 2.84, 3.84) respectively with critical values t (0.05,29)=2.05. There values of t Statistic indicate that the errors terms in case of predictor variable (x_2, x_3, x_4) do not follow the homogeneity assumption of errors variances.

Durbin-Watson'd' statistics to **test for independence of autocorrelation.**
The values of $\hat{y}_i$, e_i's (e_i-e_i-1) e_i^2 and (e_i-e_i-1)^2 were worked out and are given in the following table 4.

Table 4: Durbin-Watson 'd' statistic for autocorrelation

Year	gross cropped area(y)	Expected $\hat{y}$	ERROR (e)	e_i-e_{i-1}	e_i^2	$(e_i-e_{i-1})^2$
1983-84	22350.2	23059.45922	709.2592165		503048.6	
1984-85	22406.7	23001.80334	595.1033364	-114.156	354148	13031.56
1985-86	23015.9	23788.23108	772.3310797	177.2277	596495.3	31409.67
1986-87	22213.6	21932.50385	-281.096154	-1053.43	79015.05	1109709
1987-88	22693.8	23010.10401	316.3040082	597.4002	100048.2	356887
1988-89	22707.9	22865.75885	157.858855	-158.445	24919.42	25104.87
1989-90	22449.2	22325.27908	-123.9209172	-281.78	15356.39	79399.84
1990-91	23880.3	24133.18435	252.8843526	376.8053	63950.5	141982.2
1991-92	23089.4	22856.36756	-233.0324432	-485.917	54304.12	236115.1
1992-93	23807	23787.10407	-19.89592777	213.1365	395.8479	45427.17
1993-94	24829	24709.27095	-119.7290487	-99.8331	14335.05	9966.652
1994-95	24689	24246.63793	-442.3620677	-322.633	195684.2	104092.1
1995-96	25040	24834.0389	-205.9611024	236.401	42419.98	55885.42
1996-97	25451	25111.03125	-339.968749	-134.008	115578.8	17958.05
1997-98	25955.1	25223.57896	-731.5210429	-391.552	535123	153313.2
1998-99	20482	21681.61547	1199.615475	1931.137	1439077	3729288
1999-00	20419	21972.79118	1553.791181	354.1757	2414267	125440.4
2000-01	17870.415	18690.34689	819.9318924	-733.859	672288.3	538549.5
2001-02	19043.756	19767.82059	724.0645927	-95.8673	524269.5	9190.539
2002-03	18078.221	17604.71322	-473.5077775	-1197.57	224209.6	1434180
2003-04	19788.168	20185.03099	396.8629901	870.3708	157500.2	757545.3
2004-05	20202.639	20401.04697	198.4079749	-198.455	39365.72	39384.39
2005-06	19607.592	20494.7265	887.1345008	688.7265	787007.6	474344.2
2006-07	20113.059	19301.04427	-812.0147298	-1699.15	659367.9	2887108
2007-08	20416.071	18980.84178	-1435.229218	-623.214	2059883	388396.3
2008-09	20656.767	20416.31926	-240.4477372	1194.781	57815.11	1427503
2009-10	21411.401	20743.57931	-667.8216883	-427.374	445985.8	182648.5
2010-11	22045.593	21316.68494	-728.9080642	-61.0864	531307	3731.545
2011-12	22516.389	22081.9556	-434.4334025	294.4747	188732.4	86715.33
2012-13	23129.786	22789.12025	-340.6657548	93.76765	116053.2	8792.372
2013-14	24047.027	23093.99315	-953.0338514	-612.368	908273.5	374994.7
	684405.984	684405.9838	-0.000222168	-1662.29	13920226	14848094

The calculated value or Durbin-Watson 'd' statistic Was obtain from table as d = 1.07 for (k, n) = (4,31) the table value of 'd' statistic at α = 0.05 level of significance for one tailed test were given as (d_L, d_U) = (1.160, 1.735) thus, we see that the calculated value of 'd' statistic (1.07) d smaller than tabulated value of 'd' statistic (d_L, d_U) = (1.160,1.735). hence the null hypothesis if inpendence of autocorrelation in declared significance and finally conclude that the errors involved in the estimation of gross cropped areas y are autocorrelation if the error occurred in any years in depending open the error occurred in previous years.

Conclusion

The point wise conclusions obtain this investigation are reported as below.

1. The multiple regression analysis reveals that all the predictor variable size forest area (x_1, x_2, x_3, x_4) are found to be significant for influencing the gross cropped area (y).
2. In fitted regression model, the errors occurred follow the normality assumption. The rank correlation test for homogeneity of errors variances give the evidence that in case of predictor variable (x_1) the homogeneity of errors variances is followed but in case of other Predictor variable (x_4) the same is not followed.
3. Durbin- Watson 'd' statistic gives the evidence that the errors occurred in the estimation of gross cropped areas y happed to be strongly autocorrelation

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