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Forecasting area, production and yield of rice in the west central table land to mid central table land zones of Odishas

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Abstract
Agriculture is the largest employer in our country, besides being an important contributor to the country's GDP. Rice is grown as a principal cereal crop in our state Odisha and here it is regarded as the staple food. To feed the exponentially growing population of our state the quantity of rice production is to be enhanced. But it has been seen that the rice area is retarding day by day due to industrialization, urbanization, construction of roads etc. The production and yield are also fluctuating over the years. In this endeavor, it has been tried to give a picture of rice on area, production and productivity of seven districts of west central table land and mid central table land of the state seasonwise. Besides, the similarity with respect to yield of rice has been studied among these seven districts along with their growth rates. Further, some univariate models have been fitted to rice area, production and yield of these districts seasonwise to forecast their near future values. This study will immensely help the policymakers for policy formulation and implementation to enhance the food security and sustainability of the people of Odisha.

Keywords: forecasting area, production, rice, Odishas

Introduction
Rice is basically a high energetic or high calorific food. This is rich in carbohydrate. The protein content of milled rice is usually 6 to 7 percent. It is having comparatively high amino acid content, then other cereals. The fat content of rice is low (0.5 to 2%) and much of fat is lost during milling. It contains a low percentage of calcium and has as much b-group vitamins as wheat. The milled rice loses valuable proteins, vitamins and minerals in milling process during which the embryo and aleurone layer are removed. Much of loss of nutrients can be avoided through par-boiling process. The by-products of rice are used for a variety of purposes. Rice bran is used as cattle feed and poultry feed. Rice hulls can be used in the manufacture of insulating materials like cardboards and are also used as litter in poultry farms.

Presently there is a global competition in rice production. The land availability is diminishing day by day and there is inherent need for increasing the production of rice. The rice area, production and yield are fluctuating due to various forces (George and Mukherjee, 1986; Ito et.al., 1989, Kalita and Baruah, 1992; Haque *et al*., 1998; Parsch and Bercerra, 1999; Niranjan *et al*, 2000 and Dutta and Das, 2005) [2]. With a view to achieve the substantial rise in the production and yield of rice, it is imperative to study the behavior of rice production (together with the factors of it) in the past for forecasting the future values. For obtaining the future values, selection of good models on rice area, production and yield and its factors are important under the prevailing decline of land area. Most of the variables of today, what we observe are equally and sequentially spaced with respect to time and space are called time series variables. Univariate modeling is quite appropriate and simple to forecast the future values of a time series variable (Pal *et al*. 2000; Parida and Pal, 2000 and Krishnankutty, 2001). This type of model essentially requires a stationary time series variable. A time series variable is said to be stationary if its mean, variance and auto-correlation function are constant over time. But in practice the time series variables are found to be non-stationary. Non-stationary variables can be transformed suitably to make stationary and the models based on it can predict the near future values precisely. Forecasting of area, production and yield of rice is very useful for the planning of future requirements of the state and of the country and hence it is necessary to model the rice area, production and yield to forecast for the future by using time series best fitted functional form.

Materials and Methods
Secondary data of rice area, production and yield of the districts coming under West Central

table land and Mid Central table land zones of Odisha were collected from different sources in accordance with the objectives delineated in the problem under study. The annual data (seasonwise) pertaining to area (‘000ha), production (‘000MTs), and productivity (kg/ha.) on rice of the seven districts (Angul, Bargarh, Bolangir, Deogarh, Dhenkanal, Sambalpur and Sonepur) of Odisha for 10 years (2000-01 to 2009-10) were collected from the Agriculture Statistics of Odisha, Directorate of Agriculture and Food Production and Bureau of Economics and Statistics, Govt. of Odisha, Bhubaneswar.

Results and Discussions

The historical timeseries data for 10 years (2000-01 to 2009-10) on area, production and yield of rice was subjected to fit the 25 models (Appendix I) to forecast for the future (2 years i.e. 11^{th} and 12^{th} year) by employing the ordinary least squares method. To diagnose the best suitable model out of the 25 models the first 8 years data were used. The global properties on R^2 and Adjusted R^2 were evaluated and considered to judge the best model. Based on the best model the last two years observations were estimated and the relative per cent error of forecasting was computed. The models which were fitted best and whose forecasting error was minimum were refitted based on all the 10 years. While selection of best model the percentage variability into data was also taken into account. The best model was chosen for area, production and yield of the districts seasonwise were used to forecast for the 11^{th} and 12^{th} year i.e. 2010-11 and 2011-12.

The results emanated while fitting, judging and selection of the best models were given in Table 1. The best suitable models were varying for the seasons under area, production and yield in the districts. Out of the fitted models, the models whose relative forecast error percent was minimum was accepted to refit the model using the 10 years data

Fore casting the area, production and yield of rice

Table 1: Estimated models and its parameters at diagnostic stage based on first part of observations (first 8 years)

Districts	Variables	Seasons	Model no.	Name of model	Fitted model	R^2	Adj. R^2	Arpfe (%)	C.v.(%)
ANGUL	Area	Autumn	25	Cauchy	$Y_t = 1/(4.9924(t - 3.4189)^2 + 0.0413)$	0.6890	0.5646	8.47-22.85	12.59
		Winter*	14	Modified Geometric	$Y_t = 89.7974\ t^{(-0.1581/t)}$	0.1739	0.0362	3.84-5.46	4.31
		Summer*	25	Cauchy	$Y_t = 1/(2.4096(t- 6.4097)^2 + 0.3578)$	0.9227	0.8712	4.89- 111.27	43.78
		Total*	6	Reciprocal Hyperbola	$Y_t = t/(9.1082t – 2.0968)$	0.0258	0.1365	5.13-10.12	5.08
	Production	Autumn*	6	Reciprocal Hyperbola	$Y_t = t/(4.7068t + 0.0766)$	0.2551	0.0420	3.60-39.56	43.18
		Winter*	6	Reciprocal Hyperbola	$Y_t = t/(7.5622t + 1.8289)$	0.2665	0.1442	8.84-17.22	42.21
		Summer*	6	Reciprocal Hyperbola	$Y_t = t/(0.1310t + 0.5491)$	0.9551	0.9461	45.53-491.21	56.50
		Total*	6	Reciprocal Hyperbola	$Y_t = t/(6.0324t + 0.0146)$	0.3035	0.1874	4.36-27.30	41.73
	Yield	Autumn*	6	Reciprocal Hyperbola	$Y_t = t/(8.8620t + 2.0022)$	0.3574	0.2503	21.70-44.72	43.58
		Winter*	6	Reciprocal Hyperbola	$Y_t = t/(6.0479t + 1.6635)$	0.3287	0.2168	9.28-19.08	41.65
		Summer	25	Cauchy	$Y_t = 1/(9.0511(t- 5.5149)^2 + 0.0000)$	0.7110	0.5954	14.69-15.07	16.38
		Total*	6	Reciprocal Hyperbola	$Y_t = t/(2.0812t + 2.1505)$	0.4363	0.3424	3.86-44.87	39.97
BARGARH	Area	Autumn*	14	Modified Geometric	$Y_t = 64.0769\ t^{(-0.1369/t)}$	0.0237	0.0710	6.39-7.14	4.00
		Winter*	20	Modified Hoerl	$Y_t = 216.\ 9880.\ 0.8133^{(1/t)}.\ t^{-0.0935}$	0.4279	0.1990	7.26-7.63	3.04
		Summer*	14	Modified Geometric	$Y_t = 53.3524\ t^{(0.4313/t)}$	0.4158	0.3184	13.13-193.59	24.19
		Total*	7	2^{nd} Order Hyperbola	$Y_t = 289.4049 + 71.0911/t – 66.92/t^2$	0.4285	0.1998	5.10-12.20	4.69
	Production	Autumn*	6	Reciprocal Hyperbola	$Y_t = t/(6.6538t + 0.0710)$	0.4903	0.4053	10.08-31.61	43.35
		Winter*	17	Logarithmic	$Y_t = 201.1038 +76.7383 \log t$	0.3290	0.2171	0.46-3.80	28.12
		Summer*	6	Reciprocal Hyperbola	$Y_t = t/(5.3859t + 9.6951)$	0.1866	0.0510	21.63-139.61	24.82
		Total*	10	Power	$Y_t = 379.9543\ t^{0.2375}$	0.4171	0.3200	5.05-28.16	21.86

Table 1: continued

Districts	Variables	Seasons	Model no.	Name of model	Fitted model	R^2	Adj. R^2	Arpfe (%)	C.v. (%)
BARGARH	Yield	Autumn*	6	Reciprocal Hyperbola	$Y_t = t/(3.4791t + 4.5464)$	0.5393	0.4627	0.11-18.62	43.14
		Winter*	17	Logarithmic	$Y_t = 1154.0425 +434.5904 \log t$	0.4514	0.3599	36.52-38.74	23.68
		Summer*	8	Parabola	$Y_t = 3155.1964-207.7321t+ 27.9100t^2$	0.5691	0.3968	56.33-57.18	11.57
		Total*	18	Reciprocal Logarithmic	$Y_t =1/(2.3169 – 3.5113 \log t)$	0.5173	0.4369	0.74-35.30	20.54
BOLANGIR	Area	Autumn*	7	2^{nd} Order Hyperbola	$Y_t = 87.0480 – 23.3550/t + 19.0500/t^2$	0.0723	0.2988	11.52-11.88	6.80
		Winter	7	2^{nd} Order Hyperbola	$Y_t = 139.2866 – 30.4902/t +21.4800/t^2$	0.5530	0.3741	1.02-1.95	2.59
		Summer*	10	Power	$Y_t = 0.9732\ t^{0.6519}$	0.4847	0.3988	1.05-24.19	51.27
		Total*	24	Gamma	$Y_t = 15.7069\ (t/0.0000)^{0.0000.}\ \exp(t/0.0000)$	0.4848	0.2788	1.57-7.23	3.54
	Production	Autumn*	1	Straight line	$Y_t = 24.8350 +9.0075t$	0.5248	0.4456	30.39-44.02	40.37
		Winter*	1	Straight line	$Y_t = 74.3874 +24.8366t$	0.4527	0.3615	26.90-34.07	42.25
		Summer*	1	Straight line	$Y_t = 1.1728 +0.7496t$	0.6303	0.5687	3.89-10.90	51.38
		Total*	1	Straight line	$Y_t = 100.3953 +34.5938t$	0.4834	0.3973	29.80-32.11	41.39
	Yield	Autumn*	1	Straight line	$Y_t = 293.6785 +110.5714t$	0.5067	0.4244	20.45-33.15	41.92
		Winter*	1	Straight line	$Y_t = 590.1785 +178.6547t$	0.4205	0.3239	30.02-33.30	41.97
		Summer*	25	Cauchy	$Y_t = 1/(-1.1530(t- 3.6254)^2 + 0.0000)$	0.7109	0.5953	54.73-215.28	15.86
		Total*	1	Straight line	$Y_t = 2295.0000 +363.1666t$	0.5679	0.4958	17.90-29.71	41.50
DEOGARH	Area	Autumn	25	Cauchy	$Y_t = 1/(8.2311(t- 3.6502)^2 + 0.0431)$	0.7037	0.5851	14.26-17.27	14.15

		Winter*	1	Straight line	$Y_t = 25.4857 + 0.3285t$	0.2195	0.0894	4.80-23.27	7.14
		Summer*	25	Cauchy	$Y_t = 1/(0.5948(t - 5.7220)^2 - 1.0890)$	0.6626	0.5276	96.93-155.00	5.57
		Total*	6	Reciprocal Hyperbola	$Y_t = t/(0.0199t + 7.5035)$	0.0234	0.1394	1.45-27.62	34.39
	Production	Autumn*	6	Reciprocal Hyperbola	$Y_t = t/(4.6959t + 6.2200)$	0.3704	0.2654	2.36-320.03	33.25
		Winter*	18	Reciprocal Logarithmic	$Y_t = 1/(0.0711 - 2.6889 \log t)$	0.4210	0.3245	67.24-99.55	38.59
		Summer*	25	Cauchy	$Y_t = 1/(0.7645(t - 5.6730)^2 - 1.7710)$	0.6727	0.5417	61.12-99302.83	28.84
		Total*	6	Reciprocal Hyperbola	$Y_t = t/(1.2939t + 3.4447)$	0.4279	0.3326	22.38-72.57	96.86

Table 1: continued

Districts	Variables	Seasons	Model no.	Name of model	Fitted model	R^2	Adj. R^2	Arpfe (%)	C.v. (%)
Deogarh	Yield	Autumn*	24	Gamma	$Y_t = 9.5250\ (t/1.4012)^{0.0000.} \mathrm{Exp}(t/1.4012)$	0.6423	0.4992	10.14-14.06	30.65
		Winter*	24	Gamma	$Y_t = 2.0351\ (t/- 6.9548)^{0.0000.} \mathrm{Exp}(t/- 6.9548)$	0.8189	0.7464	36.60-85.65	38.28
		Summer*	18	Reciprocal logarithmic	$Y_t = 1/(1.1359 - 2.7374 \log t)$	0.8251	0.7960	43.32-45.31	45.14
		Total*	6	Reciprocal hyperbola	$Y_t = t/(2.0823t + 3.6906)$	0.5786	0.5084	18.14-32.17	44.09
Dhenkanal	Area	Autumn*	13	Super geometric	$Y_t = 16.3383\ t^{(-1.0516t)}$	0.4107	0.3125	27.99-39.39	18.38
		Winter*	5	Hyperbola	$Y_t = 99.9459 + 7.9997/t$	0.4517	0.3603	0.12-1.76	3.26
		Summer*	5	Hyperbola	$Y_t = 2.1112 - 0.9346/t$	0.1043	0.0450	60.01-158.69	65.84
		Total*	5	Hyperbola	$Y_t = 116.5963 + 8.9331/t$	0.3217	0.2086	2.03-7.00	4.42
	Production	Autumn*	6	Reciprocal hyperbola	$Y_t = t/(6.8273t + 8.0900)$	0.2836	0.1643	26.16-1944.80	36.84
		Winter*	10	Power	$Y_t = 75.6028\ t^{0.4500}$	0.3119	0.1972	24.34-97.82	37.77
		Summer*	17	Logarithmic	$Y_t = 1.8124 + 1.4871 \log t$	0.2756	0.1549	46.46-11432.39	64.29
		Total*	10	Power	$Y_t = 85.3705\ t^{0.4361}$	0.3045	0.1886	4.83-21.65	36.97
	Yield	Autumn*	6	Reciprocal hyperbola	$Y_t = t/(8.6861t + 1.5360)$	0.3946	0.2937	1.38-11.72	30.44
		Winter*	10	Power	$Y_t = 708.852\ t^{0.4785}$	0.3472	0.2384	19.19-26.09	36.46
		Summer*	7	2nd order hyperbola	$Y_t = 3306.2226 - 6806.3205/t + 5167/t^2$	0.8839	0.8375	8.74-34.18	22.85
		Total*	1	Straight line	$Y_t = 2684.1785 + 365.9880t$	0.5981	0.5311	23.28-26.12	37.83
Sambalpur	Area	Autumn	25	Cauchy	$Y_t = 1/(1.8534(t - 3.1211)^2 + 0.0207)$	0.6760	0.5464	14.58-21.10	8.96
		Winter	18	Reciprocallogarithmic	$Y_t = 1/(1.2299 - 5.3507 \log t)$	0.5076	0.4255	6.39-9.55	4.43
		Summer*	1	Straight line	$Y_t = 7.9742 + 1.3457t$	0.3416	0.2318	22.12-28593.86	52.50
		Total*	6	Reciprocal hyperbola	$Y_t = t/(6.6333t + 6.7309)$	0.3599	0.2532	6.86-13.61	5.57
	Production	Autumn*	6	Reciprocal hyperbola	$Y_t = t/(7.3789t + 5.8361)$	0.7755	0.7381	8.95-168.14	38.15

Table 1: continued

Districts	Variables	Seasons	Model no.	Name of model	Fitted model	R^2	Adj. R^2	Arpfe(%)	C.v.(%)
Sambalpur	Production	Winter*	6	Reciprocal hyperbola	$Y_t = t/(3.6416t + 1.1573)$	0.8068	0.7746	4.11-110.63	32.08
		Summer*	1	Straight line	$Y_t = 11.7475 + 6.4500t$	0.3891	0.2872	35.79-49755.36	69.25
		Total*	6	Reciprocal hyperbola	$Y_t = t/(2.4004t + 7.3420)$	0.7172	0.6701	18.99-74.03	31.16
	Yield	Autumn*	6	Reciprocal hyperbola	$Y_t = t/(3.1261t + 2.7106)$	0.8127	0.7815	14.73-140.63	36.81
		Winter*	6	Reciprocal hyperbola	$Y_t = t/(3.4496t + 8.9482)$	0.7563	0.7157	2.46-91.98	31.22
		Summer*	1	Straight line	$Y_t = 2039.4285 + 175.7380t$	0.4106	0.3124	18.61-81.05	23.84
		Total*	1	Straight line	$Y_t = 3569.1428 + 455.4404t$	0.5895	0.5211	33.89-58.91	29.75
Sonepur	Area	Autumn*	6	Reciprocal hyperbola	$Y_t = t/(6.7979t - 1.8689)$	0.0001	0.1665	1.90-2.49	7.17
		Winter	6	Reciprocal hyperbola	$Y_t = t/(1.1333t + 2.6127)$	0.8679	0.8459	2.49-4.64	5.65
		Summer	6	Reciprocal hyperbola	$Y_t = t/(3.8924t + 0.0188)$	0.4921	0.4075	11.08-14.21	17.37
		Total	6	Reciprocal hyperbola	$Y_t = t/(7.7645t + 1.8717)$	0.7834	0.7473	0.16-1.39	6.67
	Production	Autumn*	1	Straight line	$Y_t = 8.4896 + 1.0628t$	0.2856	0.1666	13.80-14.77	80.60
		Winter*	1	Straight line	$Y_t = 77.7221 + 13.7670t$	0.5829	0.5134	10.90-43.28	29.33
		Summer	13	Super geometric	$Y_t = 40.7824\ t^{(0.0365t)}$	0.5876	0.5189	6.46-7.58	32.13
		Total	1	Straight line	$Y_t = 117.7532 + 20.3201t$	0.6439	0.5845	7.32-21.84	17.18
	Yield	Autumn*	1	Straight line	$Y_t = 558.0714 + 77.0119t$	0.3040	0.1881	16.50-25.07	33.02
		Winter*	1	Straight line	$Y_t = 1106.3928 + 129.8571t$	0.4482	0.3562	4.20-32.89	26.33
		Summer*	1	Straight line	$Y_t = 2106.1785 + 39.9047t$	0.1145	0.0330	21.59-22.08	18.46
		Total*	1	Straight line	$Y_t = 3770.6428 + 246.7738t$	0.4530	0.3618	0.70-4.98	14.45

The final best fitted models with its parameter as well as the forecast values were presented in Table 2. The forecasted values on area, production and yield of rice in the seasons showed variation of increasing trend, decreasing trend or stagnant. The models (Table 1) marked with asterisk (*) didn't fit as revealed from R^2, Adj R^2, C.V. and ARPFE values. The best parsinomonious models were selected based on having R^2 (>50%), ARPFE (< 15%) and C.V. (<20%). The models which didn't fit for area, production and productivity may be searched in future for its best model.

Table 2: Final Fitted Models and its parameters based on all observations (based on 10 years) and forecasted values

Districts	Variables	Seasons	Model No.	Name of model	Fitted Model	R^2	Adj. R^2	Forecasted values for the years	
								11	12
Angul	Area	Autumn	13	Super Geometric	$Y_t = 24.4388\ t^{(-0.0120t)}$	0.5133	0.4524	17.77	17.04
	Yield	Summer	25	Cauchy	$Y_t = 1/(0.000(t- 5.4391)^2 + 0.000)$	0.6792	0.5875	1226.95	1059.46
Bolangir	Area	Winter	7	2nd Order Hyperbola	$Y_t = 139.90 – 33.33/t + 23.75/t^2$	0.6151	0.5052	137.07	137.29
Deogarh	Area	Autumn	25	Cauchy	$Y_t = 1/(0.000(t- 3.371)^2 – 0.0446)$	0.7771	0.7134	14.09	12.77
Sambalpur	Area	Autumn	20	Modified Hoerl	$Y_t = 73.5445.\ 0.6179^{(1/t)}\ t^{-0.2325}$	0.4835	0.3359	40.27	39.61
		Winter	25	Cauchy	$Y_t = 1/(0.0000(t-5.8296)^2 + 0.0112)$	0.6082	0.4963	79.55	76.17
Sonepur	Area	Winter	6	Reciprocal Hyperbola	$Y_t = t/(0.0114t + 0.002)$	0.8147	0.7915	85.48	85.61
		Summer	1	Straight line	$Y_t = 17.9093 +1.0567t$	0.6028	0.5531	29.53	30.59
		Total	6	Reciprocal Hyperbola	$Y_t = t/(0.0077t + 0.0019)$	0.8035	0.7845	126.33	126.56
	Production	Summer	8	Parabola	$Y_t = 40.4414 + 0.7702t + 0.4532t^2$	0.7928	0.7336	103.75	114.95
		Total	1	Straight line	$Y_t = 129.316 +16.84t$	0.6723	0.6314	314.56	331.40

Conclusion

Based on the results and discussion, it was found that the scenario on rice area, production and yield of the districts in the three seasons as well as on the total was not blooming. The area under rice cultivation was decreasing day by day due to industrialization, urbanizations, construction of roads, change of cropping pattern, scarcity of rainfall, drought, flood etc. The rice area as well as production was found to be decreasing in its absolute value as well as in the growth rate. The yield of rice was also found to be stagnant. Based on the rice yield the districts were grouped into four clusters in Autumn and Winter seasons and into six groups in Summer season. But they were not having similar yields even in the nearby districts. All the seven districts covered and their seasons didn’t follow any particular model. Under these scenario and findings there is need of more emphasis on cultivation of rice in these districts to boost production as well as yield in the prevailing and diminishing availability of land under rice cultivation. More and more area should be covered under rice cultivation. Sufficient inputs should be provided to the farmers and they are to be encouraged to go for rice cultivation. Awareness is needed for them not to go for non-food crops and cash crops cultivation. Government subsidies, fertilizers, good quality planting materials are to be made available easily along with pesticides, insecticides etc. to boost their production. Which will let our state’s and country’s economy to grow.

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