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RESEARCH ARTICLE

TIME SERIES ANALYSIS OF VEGETABLE PRODUCTION AND FORECASTING USING ARIMA MODEL

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ABSTRACT

In the present study, time series analysis was used to assess the trend of vegetable production in terms of acreage and production in the feeder zones of Chennai city. The trend of two zones [(zone 1 - Kancheepuram district) & (zone 2 -Thiruvallur district)], was evaluated by the statistical (Paired t) test. Auto Regressive Integrated Moving Average (ARIMA) Model was used to forecast the area and production of vegetables in the selected zones. From the analysis, the ARIMA (0, 1, 2) model is suitable for the cultivation area of the zone 2 and for zone 1 ARIMA (2, 0, 1) model is suitable. ARIMA (2, 0, 1) model is highly suitable for the vegetable production of both the zones. The model performances are validated by comparing the regression co-efficient values. While the model was used for forecasting for the period 2011-12 to 2014-15, decreasing trend was found in cultivated area and production of vegetables in zone 1 however in zone 2, increasing trend was found in cultivated areas whereas decreasing trend was found for the vegetable production. Hence, it can be concluded that if this situation is remaining the same for a long time then the further cultivation of vegetable crops will no longer be possible in both the zones.

INTRODUCTION

Indian agriculture is increasingly getting influenced more by economic factors and is characterized by small farm holdings (Hazra, 2001). Vegetables are the best resources for overcoming micronutrient deficiencies and provide smallholder farmers with much higher income and more jobs per hectare than staple crops (AVRDC, 2006). India's total vegetable acreage and production for the fasli (Agricultural) year 2010-2011 are $8494.6*10^3$ha and $146554.5*10^3$t respectively, of which the Tamil Nadu state fraction is $277.3*10^3$ha and $8279.9*10^3$t which is nearly 3% of cultivation area and 5% of vegetable production of the country. In the state, the vegetable cultivation area ranges from 100-300$*10^3$ ha and the production ranges from 5000 to 10000$*10^3$t coming third in acreage and second in production. Chennai city is the capital of Tamil Nadu state where the government and NGO's play a vital role, in addition to the above, the private sectors are also booming (i.e. Automobiles, information technology, medical and tourism etc.,). In addition to that a sustained economic growth, rising per capita income and growing urbanization are apparently causing a shift in the consumption patterns in favor of high-value commodities like fruits, vegetables, meat and fish products from staple food such as rice, wheat and cereals. Industrialization stimulates the high population density in the urban areas and makes the demand for food items.

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The population of the city for the year 1901 was 5.41lakhs and for the year 2011was 46.81lakhs. It has been projected about 50.57lakhs for the year 2021. The Decadal Growth rate of the city population between the years 2001 to 2011 was 7.76%. The consumption of fruit, vegetables and meat has increased considerably. The demand for these items during certain period of the year is so high. The vegetables are transported from different neighboring districts to meet the needs of the local residents of the city. For this study, the two zones (Kancheepuram and Thiruvallur districts) were selected which are very close to the Chennai city and the trend of vegetable production was analyzed and forecasted. Time series analysis was used to find the trend of vegetable production. Number of attempts were made to the model and to forecast the various agricultural crops using ARIMA (p d q) models. The model was used to forecast the sugarcane yield in Pakistan (Yaseen *et al.,* 2005). Two years back, the cultivation area, production and productivity of sugarcane have been forecasted using ARIMA model in the Tamil Nadu state (Suresh and Krishnapriya, 2011).

MATERIALS AND METHODS

The main objective of this paper was to analyze the trend of vegetable production in the feeder zones of the city. The data used in the present study have been acquired from the state agriculture department for the year 2000-2011. Linear and compound regression equation was derived to analyze the secondary data.

Time determine the method, Auto Regressive Integrated Moving Average (ARIMA) Model was used to forecast the area and production and it can be denoted by ARIMA (p, d, q). Here p indicates the order of the autoregressive part, d indicates the amount of differencing and q indicates the order of the moving average part. Based on trial and error method, the values of (p d q) were changed such as (1 0 1), (0 1 1), (1 1 0), (1 0 2), (0 1 2), (1 2 0), (2 0 1), (0 2 1) & (1 1 0) respectively and the regression coefficient values were compared. High regression coefficient value indicates that the model prediction is good.

In this study, several software was applied as follows;

- Microsoft Excel - To create an attribute database
- SPSS 21 - To analyze and to forecast
- Arc GIS 9.3 - To digitize the study zone

RESULTS AND DISCUSSION

Table 1 shows the production and productivity of each zone. Table 2 shows the results obtained from the descriptive statistical analysis of the data.

For the inferential analysis, Paired t test was carried out to check whether the difference in area and production in the two districts is significant or not. The correlation coefficient value of the cultivated area in both the district is 0.469 and for the vegetable yield is 0.626. It denotes that there is a positive correlation between two zones. From the inferential analysis, the association among the two zones in terms of cultivation area and production of vegetables is not significant. Figure 1 illustrates the location of the selected zones. Figure 2 and 3 are the time series plot of vegetable cultivation area and production in both the districts.

In the Zone 1, the area of vegetable cultivation is more than a thousand hectares during the year 2003 to 2005 and then it is in decreasing trend from the year 2006-2007. Similarly in Zone 2 the vegetable cultivation area is decreased from the year 2006-2007 and drastically it increased during the year 2010-2011. In both the zones, the area of cultivation is slightly increased from the year 2009-2010. In the Zone 1, the maximum area goes up to more than 1600ha and the production goes up to more than 20,000t and in Zone 2 the maximum area goes nearly 1000ha and the production goes below 16,000t range.

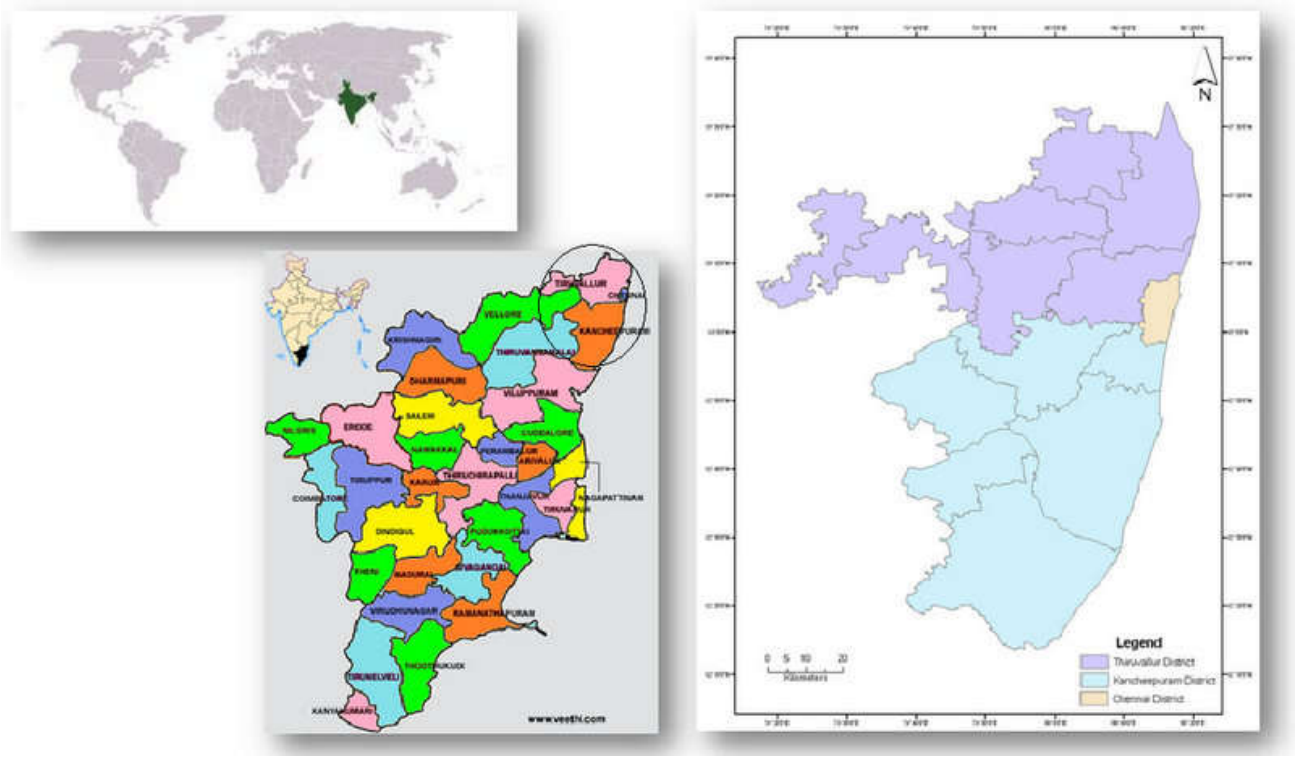


Figure 1. Location map of study zones (Kancheepuram and Thiruvallur districts)

Table 1. Cultivation Area and Production of Vegetable Crops in Zone 1 and 2

Year	Zone 1 (Kancheepuram)		Zone 2 (Thiruvallur)	
	Area (ha)	Production (t)	Area (ha)	Production (t)
2001-02	837	12221	871	11403
2002-03	871	11409	720	11588
2003-04	1750	21724	847	11762
2004-05	1322	20813	719	13552
2005-06	1507	17812	821	11806
2006-07	397	5093	484	7884
2007-08	359	4074	490	5237
2008-09	276	3132	448	4780
2009-10	245	2948	655	8975
2010-11	406	6689	1030	15196

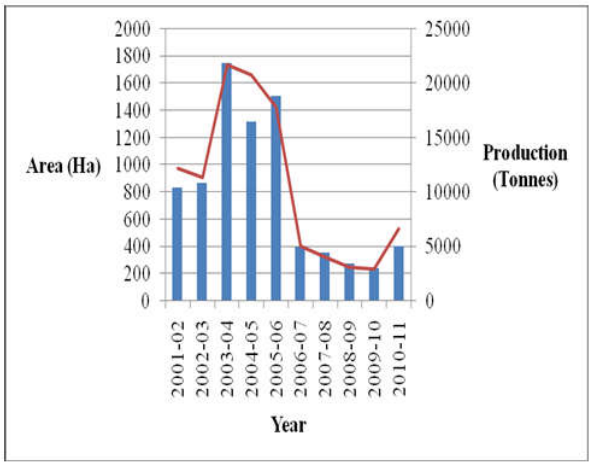


Figure 2. Time series plot of cultivated area and production in Zone 1 (Kancheepuram District)

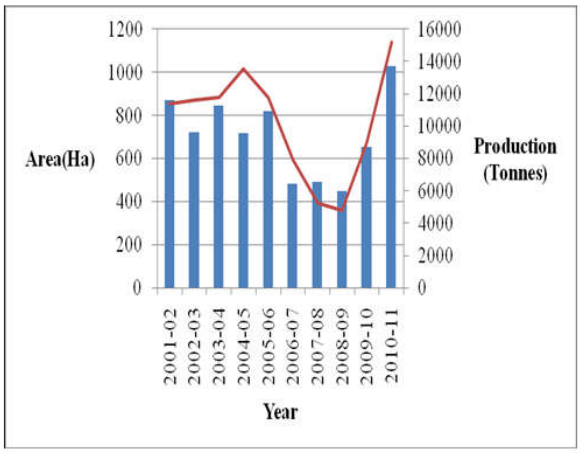


Figure 3. Time series plot of cultivated area and production in Zone 2 (Thiruvallur District)

Table 2. Descriptive Statistical analysis results

Minutiae	Kancheepuram (Zone 1)	Thiruvallur (Zone 2)
Min Area (ha)	245	448
Max Area (ha)	1750	1030
Min Production (t)	2948	4780
Max Production (t)	21724	15196
Mean (μ) Area	797	708.5
Mean (μ) Production	10591.5	10218.3
Std Deviation (σ) Area	555.4	191.7
Std Deviation (σ) Production	7347.5	3423.1

Table 3. Iterative Method -R^2 Value

ARIMA Model (p d q)	Zone 1		Zone 2	
	Area	Production	Area	Production
1 0 1	0.421	0.568	0.085	0.644
0 1 1	0.337	0.406	0.142	0.676
1 1 0	0.300	0.406	0.148	0.585
1 0 2	0.526	0.615	0.190	0.580
0 1 2	0.309	0.465	0.418	0.715
1 2 0	0.109	0.135	0.194	0.682
2 0 1	0.597	0.747	0.404	0.839
0 2 1	-0.016	0.268	0.067	0.688
2 1 0	0.338	0.410	0.201	0.764

From the graphs, it is apparently shown that in Zone 2, there is no sudden change in the cultivated area.

Also it shows that, the sustainability of vegetables in terms of area and production is poor in Zone 1 when compared to Zone 2. Figure 4 and 5 illustrate the graphical representation of the comparison of Zone 1 & 2 in terms of area and yield of vegetable cultivation. The linear equation derived from the trend line shows that the area and production are in decreasing trend in both the zones. Simple linear and compound regression equation has been generated for both the zones and forecasted using ARIMA model with 95% confidence limits in an SPSS 21 environment. The simple linear equation is

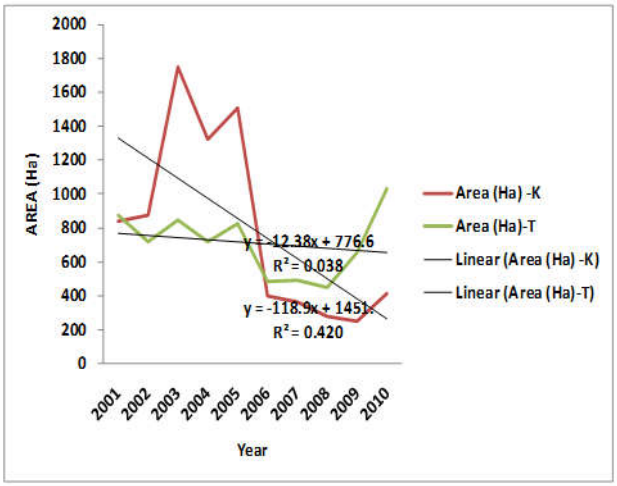
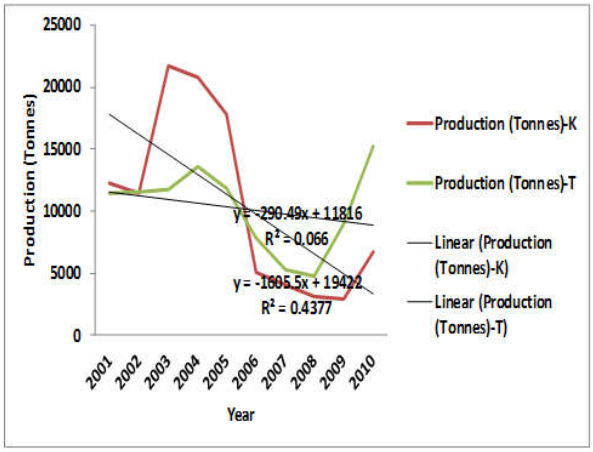


Figure 4. Time series plot of vegetable cultivation area between zone 1 and 2



Model for Vegetable Cultivation in Zone 1

Figure 5. Time series plot of vegetable production between zone 1 and 2

Y=a+bt

Y=1451. 33-118.97X ---------- 1

Compound equation is
$Y=a * (b)^{t}$

$Y=1706.734* (0.834)^{t}$---------- 2

Equation 1 and 2 shows the linear and compound regression equation for the cultivation area of zone 1 (Kancheepuram district). From the linear equation, It shows that every year the area decreased (-118.97) times. The R^2 value of the linear equation is 0.421 and for compound regression is 0.559.

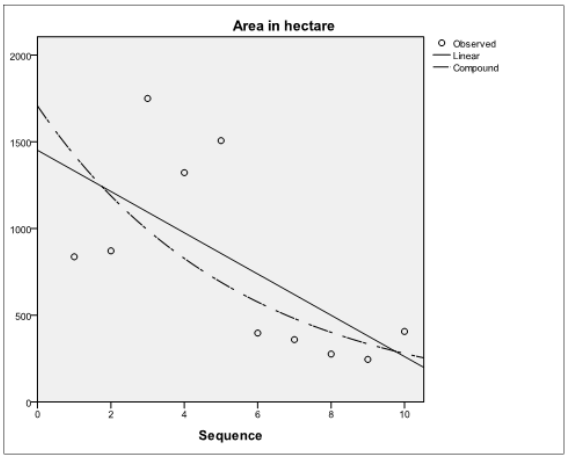


Figure 6. Observed Vegetable Cultivation Area in Zone 1

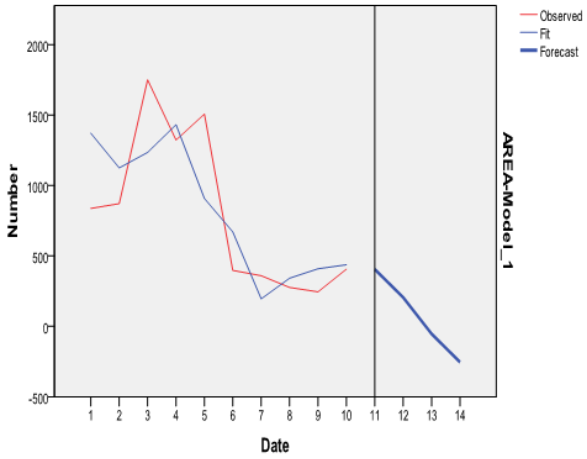


Figure 7 . Forecasted Vegetable Cultivation Area in Zone 1 – ARIMA (2 0 1)

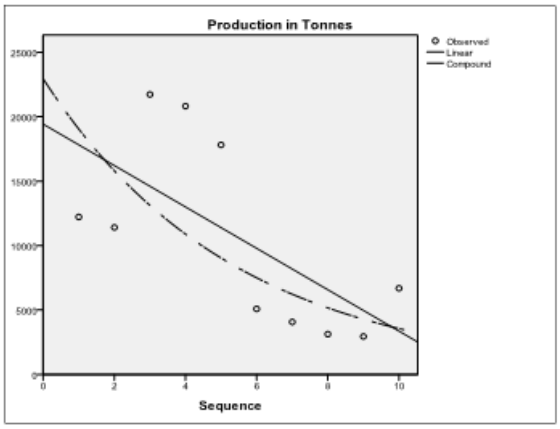
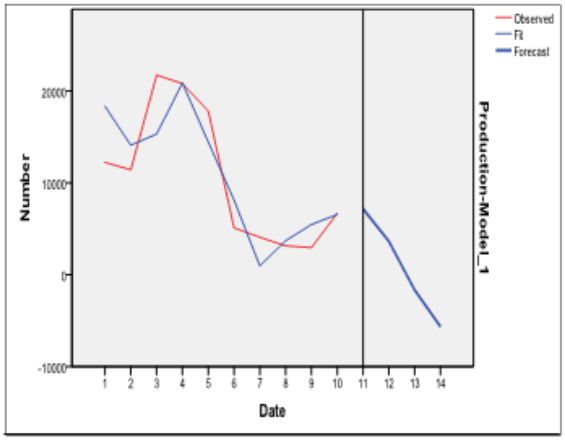


Figure 8. Observed Vegetable Production in Zone 1



Model for Vegetable Cultivation in Zone 2

Figure 9. Forecasted Vegetable Production in Zone 1 - ARIMA (2 0 1)

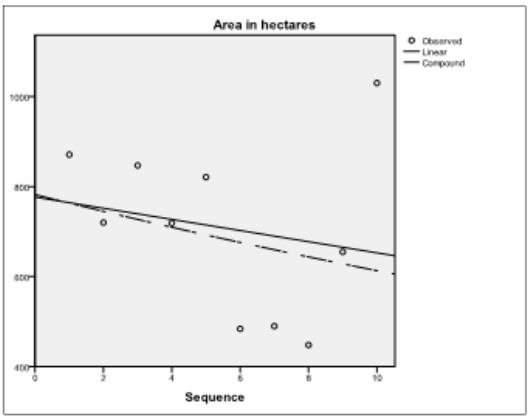


Figure 10. Observed Vegetable Cultivation Area in Zone 2

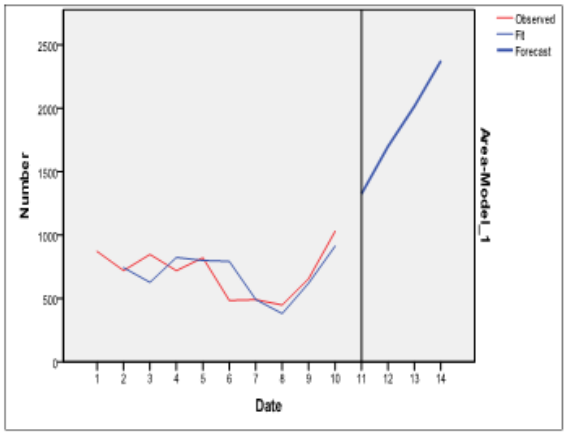


Figure 11. Forecasted Vegetable Area in Zone 2

Table 4. Forecasted Results

Year	2011-12		2012-13		2013-14		2014-15	
Zone	1	2	1	2	1	2	1	2
Forecasted Area (ha)	404	1326	205	1699	0	2016	0	2374
Forecasted Production (t)	7158	16333	3618	11612	0	5036	0	1604

2 – ARIMA (0 1 2)

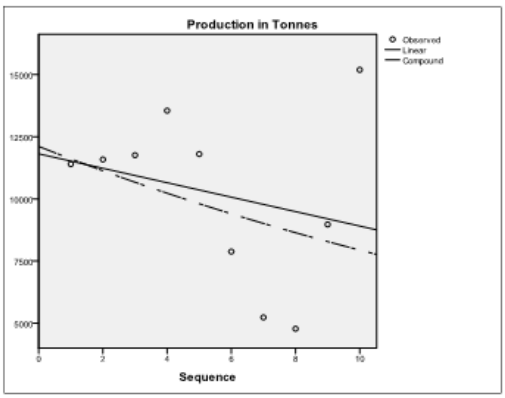


Figure 12. Observed Vegetable Production in Zone 2

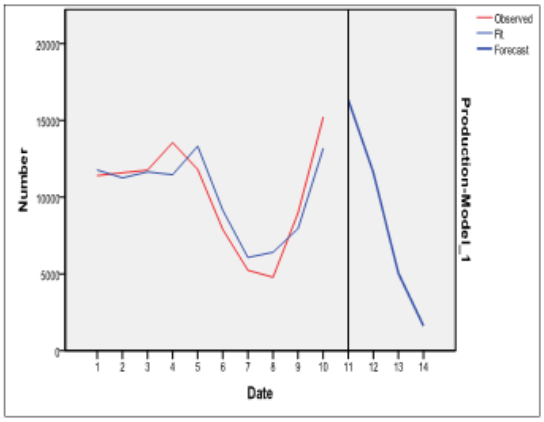


Figure 13. Forecasted Vegetable Production in Zone 2 - ARIMA (2 0 1)

Figure 6, 8, 10 and 12 shows the observed values of area and production for both the zones and their linear and compound regression lines. Figure 7, 9, 11 and 13 illustrates the forecasted values of area and production for both the zones. The area will be increased and the production will be decreased considerably for zone 2. Table 3 shows the model R^2 values obtained from the iterative process. Table 4 shows the results obtained from the ARIMA model. It indicates that the predicted values of cultivation area and production for zone 1 and 2.

Conclusion

Trend of vegetable production was analyzed using time series analysis. The parsimonious models for given data are ARIMA (2 0 1) (Autoregressive Integrated Moving Average model of auto regressive order 2, differencing 0 and moving order 1) and ARIMA (0 1 2).

The model result shows that in zone 1 (Kancheepuram district), the cultivated area and production both are in decreasing trend and in zone 2 (Thiruvallur district), the area is in increasing trend and the production is in decreasing trend. If the same trend is continuing, surely it will conduce to the failure in vegetable production in both the zones. Hence, it is recommended that the vegetable cultivation practices and cropping pattern should be analyzed to increase the productivity of vegetable crops in the selected zones.

Acknowledgements

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