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FORECASTING DEMAND AND SUPPLY OF ONION IN PAKISTANI PUNJAB

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The present study was designed for estimation of future projections regarding onion area, production and consumption in Punjab, Pakistan. The ARIMA model was employed for obtaining such forecasts. Consumption and production gap of onion was also estimated for up-to the year 2025. The forecasted results entail onion area and production to be 47.484 thousand hectares and 372.403 thousand tonnes in 2025, respectively. The reliability of forecasted values of ARIMA models were ensured by comparing actual values and forecasted values for the year 2008-09. It was found that our forecasted values are appropriate with small values of standard errors. Results of the study also point out severe gap in production and consumption of onion in the coming years. The supply and demand gap can be avoided by taking appropriate measures in research and development and policy-making as well.
Keywords: Onion, ARIMA, production, consumption, projections, Punjab

INTRODUCTION

Vegetables are substantially contributing in meeting dietary needs of rising population in Pakistan. With the passage of time, vegetable consumption shows an increasing trend due to positive preference of consumers. In spite of increased vegetable consumption, per capita vegetable intake is still below the recommended level given by WHO (Bakhsh, 2007). Further, production of vegetables is not enough to meet demand of the country as a result vegetable prices are too high in these days. This situation indicates supply and demand gap in vegetable production. The supply or production projection of an agricultural commodity plays a vital role in the adjustments of supply and demand in the future. Similarly, information on future demand is also crucial to make production decision. These information on various crops help the government to make policies regarding relative price structure, production and consumption and also for establishing relations with other states of the world (Iqbal *et al.,* 2005). Forecasts of demand and supply present precise and advance information to the vegetable growers and also to the government. Moreover, this information would signify whether the variations in production and demand have stable or temporary effects on future production. Thus it may also be helpful for policy makers in choosing the proper support services for the agriculture segment (Mari, 2009). On the other hand, vegetable producers can make decision about allocation of resources in certain crop enterprise well in time. Forecasting information also helps government to make prior decision considering possible supply and demand gap in vegetable production in order to stabilize prices in the market. Pakistan is blessed with variety of vegetables throughout the year. Moreover, vegetables are important source of food nutrients i.e. vitamins, minerals and carbohydrates (Hanif et al., 2006). The consumption of vegetables in sufficient quantities is associated with taste and deliciousness. It also enhances appetite and produces fair quantity of fibres required by the human body. Vegetables are currently considered to be an imperative adjunct for maintaining fitness and valuable to guard against some degenerating ailments (Rai and Yadav, 2005).

Among vegetables, onion is one of the vital condiments extensively used in all households throughout the year. As onion is free from microbial contamination, it is usually utilized for manufacturing food. Its salt is prepared by dehydration and made use for flavouring (Rai and Yadav, 2005). Changing consumption pattern has created problem of shortage of onion in the country in the past years and the country has to import onion from the neighboring country (India) to meet the needs of the consumers. The limited supply and import from the neighboring country, namely India indicate information gap about the actual demand and supply of onion in the country. In order to tackle this problem in the coming years, there is a dire need to have accurate information about future production of onion and its demand as well in order to take timely policy actions to avoid any shortage in the country.

Various studies have been conducted to determine forecasted values of production and price of various crops using ARIMA model. For examples Shukla and Jharkharia (2011) for wholesale vegetables markets in India, Amiri et al., (2011) for prices of potato and onion in Iran, Amrutha (2009) for price of onion in India, Nochai and Nochai (2006) for oil palm price in Thailand, Sher and Ahmad (2008) for wheat production in Pakistan and Iqbal et al. (2005) for

wheat area and production in Pakistan. Ahmad (2003) estimated the impact of WTO trade liberalization on the production and export of kinnow. Further, he also estimated forecasted production and export of kinnow from Pakistan using ARIMA model. However, we found no study relating to onion production and consumption along with forecasted values in Pakistan. Thus, there is a dire need to conduct a study on future demand for and supply of onion in the country.

In this manuscript, effort has been carried out for making long-term forecast of onion area and production in the province of Punjab, Pakistan which will offer the researchers and publics with forecasted data regarding onion area and production for depicting onion acreage and production status in the future. This study also provides information on future demand for onion in the province as well, so the producers and other stakeholders will be able to make appropriate decision to avoid any supply and demand gap issue in the future.

MATERIALS AND METHODS

The time series data of area, production and consumption of onion from 1980-2007 were used in this paper. The data on area and production of onion were obtained from government statistics such as Agricultural Statistics of Pakistan and Economic Surveys. The data regarding population and consumption of onion in Punjab were taken from Punjab Development Statistics and Household Income and Expenditure Survey (HISE), respectively.

We have used the ARIMA (Auto Regressive Integrated Moving Average Model) among the various time series models available. It involves single equation regression models as well as simultaneous equation regression models for forecasting the production and consumption of onion. The ARIMA model is preferred because of its emphasis on evaluating the stochastic characteristics of the economic time series. Dieng (2008) argues that among parametric models, ARIMA model is a good technique to use in generating forecasts. In addition, the dependent variable in the ARIMA model is explicated by its own lagged values and the error terms (Gujarati, 2003). ARIMA is also termed as Box-Jenkins (BJ) methodology which explains a combination of two models i.e. auto regressive and moving average models. This is an ongoing approach as the more compound models are constructed with the outcomes of simpler ones (Ahmad *et al.,* 2005). This method has been used widely in economic research.

According to Box and Jenkins (1976), the ARIMA model is symbolized as ARIMA (p, d, q), where p represents the order of the auto regressive method, d corresponds to order of homogeneity, i.e. the number of differences taken to make the time series stationary, q signifies the order of the moving average procedure. As ARIMA is an amalgamation of both AR (Autoregressive) and MA (Moving average) processes, so the equations regarding AR and MA processes (Ahmad *et al.,* 2005) are specified below:

The AR model of order 'p' indicated by AR (p) can be written as:

$$Z^t = C + \alpha^1 Z_{t-1} + \alpha_2 Z_{t-2} + \cdots \ldots \ldots + \alpha_p \Delta^d Z_{t-p} + a_t \quad (1)$$

where a_t represents a random variable with zero mean and stable variance.

The MA model of order 'q' or MA (q) can be written as:

$$Z_t = a_t - \beta_1 a_{t-1} - \beta_2 a_{t-2} - \ldots \ldots \ldots - \beta_q a_{t-q} \quad (2)$$

The combining of above two equations yields general form of ARIMA model as:

$$\Delta d Z_t = C + \left(\alpha_1 \Delta^d Z_{t-1} + \ldots \ldots + \alpha_p \Delta^d Z_{t-p}\right) - \left(\beta_1 a_{t-1} + \cdots \ldots \beta_q a_{t-q}\right) + a_t \quad (3)$$

where 'C' is a constant,

Δ represents a difference operator such that

$$\Delta Z_t = Z_t - Z_{t-1}$$

$$\Delta^2 Z_{t-1} = \Delta Z_t - \Delta Z_{t-1}$$

$Z_{t-1} \ldots \ldots Z_{t-p}$ are values of past series (lags)

α is the coefficient to be obtained by AR model.

β is coefficient to be obtained by MA model.

This model was employed for analyzing the quantitative relationship of data and to forecast future trends of onion area and production separately up to the year 2025.

The main problem in applying ARIMA model is to choose the most suitable values for the p, d, and q. This difficulty can be partly resolved by viewing the Auto Correlation Function (ACF) and Partial Auto Correlation Functions (PACF) for the time series of the data (Pindyk & Rubinfeld, 1991). The degree of the homogeneity, (d) is estimated on the basis where the ACF comes near to zero. After estimation of "d" a stationary series Δd Z_t, its ACF and PACF are examined for determining values of q and p respectively in order to "identify" the model. After that there is need to estimate the model. The E-views 3.1 has been used to estimate the model. Diagnostic checks are also applied to obtain accurate results. The consistency of the estimated ARIMA model is confirmed by examining the residual's normality of that model. The model is affirmed a good fit when the residuals reveals white noise characteristics. Finally, the forecast regarding onion area, production and consumption are made from 2008-2025 using the outcomes of ARIMA (p, d, q) model. We have used the following assumption for these projections.

- There is absence of haphazard shocks in the economy, i.e. war, disrupted law and order and abnormal climatic state
- Agricultural price structure and polices will remain unchanged
- Consumer preferences will not alter

The gap between production and consumption of onion in Punjab is determined. The per capita consumption of onion is used to estimate total demand by multiplying per capita annual consumption with population of the concerned

year. The total supply of onion is depicted by the data regarding production of onion in Punjab. Then the difference between supply and demand for onion is taken to estimate the consumption gap of onion in Punjab. The consumption gap is also forecasted up-to 2025.

RESULTS AND DISCUSSION

Keeping in view the objectives of the study, we applied the ARIMA model to predict future production and consumption of onion in the Punjab province. Before doing this, stationarity of the data was tested as it is well documented in the literature that nearly all of the time series are non-stationary. In order to test for stationarity, the ADF (Augmented Dickey Fuller) test was employed and it showed that all the time series were stationary at the first difference, where the ADF test statistics were greater than the critical values at 1%, 5% and 10% level of significance. Further the ACF of the time series were also observed to assure the stationarity of the data series. Results of the ACF tests showed that time series data under consideration were non-stationary. As the lag length k increased, the ACF of both the data series did not fall. In order to know about the order of homogeneity, differenced time series and the ACF of differenced time series were taken. The ACF for first differenced data series showed relatively more appropriate stationary manner than the second differenced series of the data. The ACF of first differenced series fell quickly as lag length k increased. Thus, the selected value of "d" was 1 for the whole data series. The values of "p" and "q" were chosen from PACF and ACF respectively of both the series. Consequently, ARIMA (1, 1, 0), ARIMA (1, 1, 1) and (1, 1, 1) models for area, production and consumption of onion, respectively were identified.

For assuring reliability of the estimated ARIMA models, the correlogram of residuals of estimated models were taken. The correlogram of residuals exhibited stationary behavior which is an indication of white noise residuals of the models. So, the estimated ARIMA were found suitable for forecasting. In the later stage, we estimated forecasted values for 18 years. The forecasts regarding onion area and production are presented in Table 1. Table 1 implies that in 2025, the onion's area and production would be 47.484 thousand hectares and 372.403 thousand tones, respectively. We discuss forecasted values of consumption of onion and demand and supply gap later.

Further, we also estimated forecast errors in order to determine the reliability of our findings. The forecast errors were computed by taking the difference of actual and predicted production. A positive forecast error shows that real output is greater than its predicted value. Hence, the output is underestimated (Sher and Ahmad, 2008). On the other hand, a negative forecast error is an indication of overestimated model. Table 2 expresses results about actual and predicted output, forecast error and percent forecast error of ARIMA models of area and production. The forecast error for onion area is calculated to be negative so its model is overestimated whereas the forecast error of around 8 percent for onion production is positive which signifies that the model is underestimated. Illankon et al. (2011) also estimated a forecast error of 10 percent in vegetable production in Sri Lanka which is close to our estimate. In real terms, the area under onion in Punjab did not increase as it was forecasted while the production was much more than forecasted results. So, more production of onion is achieved by small increment in its area in 2008-09, which may be an outcome of technological development in vegetable production.

Table 1. Forecasted onion area and production

Years	Area of onion "000" hectares	Production of onion "000" tones
2009	36.422	277.854
2010	37.104	287.648
2011	37.794	294.697
2012	38.486	300.751
2013	39.178	306.444
2014	39.871	312.005
2015	40.563	317.519
2016	41.255	323.016
2017	41.947	328.506
2018	42.639	333.995
2019	43.331	339.482
2020	44.023	344.969
2021	44.715	350.456
2022	45.408	355.943
2023	46.100	361.430
2024	46.792	366.917
2025	47.484	372.403

Table 2. Forecast errors for forecasted onion area and production for 2008-09

	Actual output	Predicted output	Forecast error	% forecast error
Onion Area ("000" hec.)	35.3	36.421	-1.121	-3.07
Onion Production ("000" ton.)	300.5	277.85	22.65	8.15

We also used the data on onion consumption in order to know whether there is a shortage or surplus of onion in the province. Firstly, the per capita consumption was multiplied with the estimated population of Punjab to arrive at the demand for onion, while the supply of onion was depicted by the data regarding production of onion. Then, the demand for onion was subtracted from supply of onion and the negative sign in estimated values showed that there is

shortage of onion in Punjab i.e. excess of onion demand as compared to its supply. Tables 3 and 4 show that the difference between supply and demand of onion is negative which means there is shortage of onion in Punjab. In 2007, the shortage of onion was about 630 thousand tonnes. The forecasted results which are based on past trend showed that in 2025 this shortage will be about 1274 thousand tonnes. The reasons for this shortage include lower production of onion in Punjab, as Punjab ranks at number 3 in terms of onion production in Pakistan while on the other hand the consumption of onion is higher in Punjab because of dense population of Punjab as compared to other provinces of the country. These two reasons account for the shortage of onion in Punjab. This shortage is covered by supplying onion from other provinces of Pakistan mainly Sindh, which is the largest producer of onion in Pakistan.

CONCLUSIONS

The results of the present study showed that there will be amplified supply of onion in the province of Punjab in future. However, demand for onion is expected to exceed production in future as well, creating severe problem of shortage in the province. Thus, it calls for an increase in the supply of onion to fulfill the high demand of onion in the province. The need is to exploit the existing potential to boost onion production. It can be achieved through different ways. One method is to induce vegetable growers for bringing additional area under onion. This requires a little change in cropping pattern of the locality over time. Adoption of innovative production methods and latest technologies is another way to increase onion production. Advancement and adoption of innovation is a long term procedure which requires more capital to be invested in

Table 3. Consumption of onion in Punjab

Years	Population (000 Persons)	Annual per capita consumption (kg year^{-1})	Total consumption (000 tonnes)	Total production (000 tonnes)	Shortage (000 tonnes)
1980	46125	7.56	348.7	140.2	-208.5
1981	47765	7.68	366.8	143.2	-223.6
1982	49255	7.44	366.5	145.4	-221.1
1983	50786	7.80	396.1	149.5	-246.6
1984	52356	7.92	414.7	151.7	-262.9
1985	53977	8.40	453.4	163.3	-290.1
1986	55650	7.80	434.1	157.8	-276.3
1987	57376	7.92	454.4	161.2	-293.2
1988	59154	8.16	482.7	185.3	-297.4
1989	60992	8.04	490.4	143.9	-346.5
1990	62886	8.28	520.7	157.9	-362.8
1991	64829	9.00	583.5	158.1	-425.4
1992	66841	9.24	617.6	171.8	-445.8
1993	68877	9.60	661.2	182.9	-478.3
1994	70942	9.84	698.1	205.2	-492.9
1995	73010	10.08	735.9	212.1	-523.8
1996	75042	9.48	711.4	218.2	-493.2
1997	77207	10.44	806.0	225.7	-580.3
1998	74206	10.68	792.5	230.8	-561.7
1999	75987	11.16	848.0	247.6	-600.4
2000	77810	11.40	887.0	251.3	-635.7
2001	79444	11.76	934.3	225.0	-709.3
2002	80875	11.88	960.8	263.2	-697.6
2003	82330	11.76	968.2	251.2	-717.0
2004	83861	11.28	945.9	264.6	-681.4
2005	85318	9.60	819.1	306.4	-512.6
2006	86812	9.96	864.7	315.7	-548.9
2007	88289	10.08	889.9	260.5	-629.5

Table 4. Forecasted values of consumption of onion in Pakistani Punjab

Years	Population (000 Persons)	Per capita consumption (kg year^{-1})	Consumption (000 tonnes)	Production (000 tonnes)	Shortage (000 tonnes)
2009	91016	11.64	1059.4	277.854	-781.6
2010	92593	11.76	1088.9	287.648	-801.3
2011	94171	12.00	1130.1	294.697	-835.3
2012	95748	12.12	1160.4	300.751	-859.7
2013	97325	12.24	1191.3	306.444	-884.8
2014	98903	12.48	1234.3	312.005	-922.3
2015	100480	12.60	1266.1	317.519	-948.5
2016	102058	12.72	1298.2	323.016	-975.2
2017	103635	12.84	1330.6	328.506	-1002.2
2018	105213	13.08	1376.2	333.995	-1042.2
2019	106790	13.20	1409.6	339.482	-1070.1
2020	108367	13.32	1443.4	344.969	-1098.5
2021	109945	13.56	1490.8	350.456	-1140.4
2022	111522	13.68	1525.6	355.943	-1169.7
2023	113100	13.80	1560.8	361.430	-1199.3
2024	114677	13.92	1596.3	366.917	-1229.4
2025	116255	14.16	1646.2	372.403	-1273.7

research and development. Efficient use of existing resources can also help in boosting the production of onion. It implies that increase in onion production lies in enhancement of onion productivity i.e. increase in yield per unit area. Therefore, adequate scope exists for improving productivity of onion. There has been a progressive rise in area and production of onion in Pakistan. Onion serves as an important cash crop to the farmers as well as an important exportable horticultural commodity of the country. Thus, expansion of onion crop will increment farm incomes and foreign exchange income of the country.

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