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MAJOR FOOD CROPS PRODUCTION AND YIELD FORECAST IN PAKISTAN

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ABSTRACT:- This study focuses on forecasting the production and yield of food crops in Pakistan. Utilizing the "Autoregressive Integrated Moving Average" (ARIMA) model and data from 1948 to 2011. The data was obtained from Ministry of Food and Agriculture, Islamabad and various Economic Surveys of Pakistan. The result predicts that wheat (production and yield) forecast for 2029-30 to be about 37188 thousand tons and 3454 kg ha^{-1}, respectively. The rice (production and yield) forecast for 2029-30 will be about 7176 thousand tons and 2630 kg ha^{-1}, respectively. The maize (production and yield) forecast for 2029-30 will be about 5784 thousand tons and 6088 kg ha^{-1}, respectively. In short, the production growth rate of wheat, rice and maize was higher in 2012.

Key Words: Wheat; Rice; Maize; Forecasting; Autoregressive Integrated Moving Average; Production; Yield; Pakistan.

INTRODUCTION

The agriculture sector in last 50 years was ignored both in developed and developing countries, because it was considered as a traditional and outdated sector. Although in 1960s, its importance was realized and measures were taken for its development (Yaseen et al., 2005). Since 1960 the balanced growth between industrial and agriculture sector were underlined. During last few years the major crop remained the target of natural disaster as the growth of these food crops in the last four years was negative. The main food crops in Pakistan are wheat, rice and maize. Wheat is one of the major staple food and having essential station in devising agricultural policies. Wheat crop accounts for 13.1% in agriculture sector and 2.7% in overall GDP. Rice is the second major staple food crop and source of export earnings in Pakistan. It contributes 4.4% in agriculture and 0.9% in GDP (GoP, 2011).

To estimate forecast of total crop production in advance is very important for determining the prices, export-import policies and also for making possible for government to take correct measures of surplus and scarcity in the national crops production. Several studies forecast and find out constraint in the production of major food crops such as wheat, rice and maize in Pakistan. According to Muhammad (1989) and Hamid et al. (1987) in spite of these constraints in Pakistan, there are well known forecast for persistent growth in the area and yield of food crops. The ARIMA model has been commonly used to forecast future internal consumption and export to take up suitable measures in

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Pakistan (Sohail et al. (1994), Shabur and Haque (1993), Azhar et al. (1972, 1973 and 1974), Saeed et al. (2000), Boken (2000), Muhammad (2001) and Iqbal et al. (2005) also forecast wheat production and area in Pakistan.

Most of the empirical studies have proven that forecasts of ARIMA models are better than the structural models particularly in time series analysis. It is more difficult as compared to other forecasting method, as it adds the characteristic of all others methods. It is very strong method to handle any data pattern. The objective of this paper is to forecast production and yield of three major food crops (wheat, rice and maize) by using ARIMA models.

MATERIALS AND METHOD

In the present study data is collected from Ministry of Food and Agriculture, Islamabad and various Economic Surveys of Pakistan. The ARIMA model is the most commonly used model for forecasting and prediction in time series analysis. Actual time series values are used for forecasting future values are called "Auto-Regressive" process and lags of their forecast errors are called "Moving Average" process. ARIMA model is expressed as ARIMA (A, D, M), where A, D and M stands for auto regressive process, order of integration and moving average (MA) process, respectively.

A standard ARIMA model (A, D, M) used by Judge et al. (1988) can be written as follows:

$$\Delta^d Y_t = \alpha + \beta_1 \Delta^d Y_{t-1} + \beta_2 \Delta^d Y_{t-2} + \ldots\ldots + \beta_A \Delta^d Y_{t-A} + e_t - \gamma_1 e_{t-1} - \gamma_2 e_{t-2} - \ldots\ldots - \gamma_M e_{t-M} \quad (1)$$

where,

Δ^d = Order of differencing, i.e.,

ΔY_t = $Y_t - Y_{t-1}$,

$\Delta^2 Y_t$ = $\Delta Y_t - \Delta Y_{t-1}$ and so forth,

$Y_{t-1} \ldots Y_{t-A}$ = Previous observations (lags),

$\alpha, \beta_1 \ldots \beta_A$ = Parameters (constant and coefficient) to be estimated from the actual time series data. However, both the processes AR (A) and MA (M) can be written separately as follows:

$$Y_t = \alpha + \beta_1 Y_{t-1} + \ldots + \beta_A Y_{t-A} + e_t \quad (2)$$

where,

$\beta_1 \ldots \beta_A$ = Auto Regressive AR (A) coefficients to be estimated from the actual time series data and these are also used for future predictions.

While MA (M) can be written as

$$Y_t = e_t - \gamma_1 e_{t-1} - \gamma_2 e_{t-2} - \ldots - \gamma_M e_{t-M} \quad (3)$$

where,

e_t = White noise error term

$e_{t-1}, e_{t-2} \ldots e_{t-M}$ = Past white noise errors,

$\gamma_1 \ldots \gamma_M$ = Moving average (MA) coefficients to be estimated and used for future predictions.

Forecasting would be carried out by following methodology based on Salam et al. (2006). Firstly, stationarity of the variable will be tested graphically by utilizing Autocorrelation Function (ACF), Partial Autocorrelation Function (PACF) and by using Augmented Dickey-Fuller test of unit root (Dickey and Fuller, 1979). After determining the staionarity of series, the next step is to obtain an appropriate model(s) based on Box and Jenkins (1976) methodology. Then, the model(s) is identified by using both ACF and PACF and estimate through Non linear Least Square (NLS) numerical method. In estimation process uncertain models are estimated and different coefficients are observed. The estimated models are compared by using Akaike Information Criterion (AIC). The model with smallest AIC value is selected for prediction. Moreover, other diagnosing tests are also performed to check the normality and heterogeneity. Using the results of ARIMA (A, D, M), forecasts from 2012 up to 2030 is made.

RESULTS AND DISCUSSION

The area under wheat cultivation for 2010-11 was 8805 thousand hectares as against previous year which was 9132 thousand hectares and the target was set 9045 thousand hectares. It indicates a decline of 3.6% over the previous years. However, wheat production has been estimated 24.2 mt which indicate 3.9% increase over the previous year production which was 23.3 mt and target was set at 25 mt.

Area and production of rice is 2365 thousand hectares and 4823 thousand tons, respectively. However, it reveals that the area under rice is 17.9% less and production of the rice declined by 29.9% over the last year (GoP, 2011). The decrease is due to floods, besides due to decrease in area and attack of insects and pests to the crops. During 2010-11, the production and area of maize increased by 2.4% and 0.4%, respectively (GoP, 2011).

The study use ARIMA model based on four steps namely model estimation, model specification, forecast and diagnostic checking. The data relating to yield and production of food crops for last 63 years was used for modeling purpose. The first step of the modeling is to check the time series property of the data, i.e., stationarity of the data for the underlying variables. To capture the issue, unit-root test was used of all the time series. The stationarity of the variables is checked by the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979).

The variables of wheat production (W_P), rice yield (R_Y) and maize production (M_P) are non-stationary at level along with the intercept and trend term but it becomes stationary, Acquired its first difference is as it rejects the null hypothesis of non stationary at 1% level of significance. The variable of maize yield (M_Y) are non-stationary at level without the intercept and trend term but it becomes stationary, as its first difference is acquired, it rejects the null hypothesis of non-stationary at 5% level of significance (Table 1). The

Table 1. Unit Root Test (Augmented Dickey-Fuller Test, ADF)

Variables	Intercept / intercept & trend	Level	1^{st}- difference	Order of integration
W_P	Intercept & Trend	-2.79	-9.11**	I(1)
W_Y	Intercept & Trend	-3.85*	-	I(0)
R_P	Intercept & Trend	-4.12**	-	I(0)
R_Y	Intercept & Trend	-2.93	-8.36**	I(1)
M_P	Intercept & Trend	-2.55	-4.70**	I(1)
M_Y	None	3.22	-2.56*	I(1)

** and ** = Rejection of null hypothesis of unit-root at 5% and 1% level of significance, respectively.*

variables of wheat yield (W_Y) and rice production (R_P) are stationary at level along with the intercept and trend term at 5% and 1% level of significance, respectively. The results depict that all variables except wheat yield (W_Y) and rice production (R_P) are integrated of order one I (1).

All the variables discussed above are differenced stationary except wheat yield and rice production. To make them stationary, differenced series were used and first difference series showed stationarity, as a result, the value of parameter 'D' was decided to be equal to '1'. Secondly, the values of autoregressive parameter 'A' and moving average parameter 'M' were determined by seeing the correlograms peaks of partial autocorrelation function and the auto correlation function, respectively.

In food crops production and yield A, D, M values were determined for ARIMA i.e., ARIMA (0,0,1) and ARIMA (1,0,1) for wheat production and yield, respectively. In rice production and yield ARIMA (1,0,3) and ARIMA (1,0,1) were used, respectively. In maize production and yield ARIMA (1,0,1) and ARIMA (1,0,1) were used, respectively.

Model Estimation

All ARIMA models were estimated using E.views computer package (Table 2).

After estimation, it was checked whether the underlying models were properly fitted or not by applying special diagnostic checks (Box and Jenkins, 1976).

To check the quality of the forecast and whether the forecast of the present study are realistic and stable actual and forecasted values are shown with 95% confidence limits from 2012 to 2014 (Table 3).

The result showed that wheat, rice and maize production and yield

Table 2. Estimates of food crops parameters

Type	Coefficients	S.E	t-ratio
Wheat Production			
MA	-0.774	0.080	-09.646
Wheat Yield			
AR(1)	0.836	0.024	34.994
MA(1)	-0.982	0.014	-69.706
Rice Production			
AR(1)	0.432	0.121	03.574
MA(3)	0.615	0.114	05.400
Rice Yield			
AR(1)	0.729	0.092	07.887
MA(1)	-0.954	0.025	-37.523
Maize Production			
AR(1)	-0.501	0.271	-01.851
MA(1)	0.756	0.203	03.717
Maize Yield			
AR(1)	0.873	0.058	15.000
MA(1)	-1.000	0.079	-12.718

Source: Self calculation and estimation

Table 3. Forecast of wheat, rice and maize production and yield from 2012 to 2014 with 95% confidence interval

	Production (000 t)				Yield (kg ha^{-1})			
Year	Actual	Forecast	95 % Limit		Actual	Forecast	95 % Limit	
			Lower	Upper			Lower	Upper
Wheat								
2012	23473	24908	23106	26709	2714	2741	2566	2915
2013	24211	25519	23717	27320	2796	2776	2602	2951
2014	25286	26138	24336	27940	2797	2816	2642	2991
Rice								
2012	6160	5969	4501	7437	2396	2102	1802	2402
2013	5536	6348	4880	7816	2398	2154	1854	2454
2014	6798	5336	3868	6804	2437	2198	1898	2498
Maize								
2012	3401	3382	3094	3670	3639	3637	3384	3924
2013	3324	3494	3206	3782	3751	3724	3471	4012
2014	3493	3613	3326	3901	3853	3819	3566	4106

Source: self calculation

Table 4. Food crops production and yield forecast from 2012 to 2030

Year	Wheat			Rice			Maize		
	Area (000 ha)	Production (000 t)	Yield (kg ha^{-1})	Area (000 ha)	Production (000 t)	Yield (kg ha^{-1})	Area (000 ha)	Production (000 t)	Yield (kg ha^{-1})
2011	8805	24214	2750	2365	4,823	2039	917	3262	3558
2012	9088	24908	2741	2840	5969	2102	930	3382	3637
2013	9192	25519	2776	2947	6348	2154	938	3494	3724
2014	9282	26138	2816	2427	5336	2198	946	3613	3819
2015	9371	26766	2856	2542	5686	2237	952	3732	3921
2016	9461	27402	2896	2591	5886	2272	957	3855	4030
2017	9551	28047	2936	2614	6021	2303	960	3979	4145
2018	9643	28699	2976	2627	6128	2332	962	4105	4266
2019	9734	29361	3016	2637	6223	2360	964	4233	4392
2020	9826	30030	3056	2645	6313	2387	964	4363	4524
2021	9919	30708	3096	2653	6401	2413	965	4496	4661
2022	10012	31395	3136	2661	6488	2438	964	4630	4803
2023	10105	32090	3176	2670	6574	2463	963	4767	4949
2024	10199	32793	3215	2678	6660	2487	962	4906	5099
2025	10293	33504	3255	2686	6746	2511	961	5047	5254
2026	10387	34224	3295	2695	6832	2535	959	5190	5413
2027	10482	34953	3335	2703	6918	2559	957	5335	5576
2028	10577	35689	3374	2712	7004	2583	955	5483	5743
2029	10672	36435	3414	2720	7090	2606	952	5632	5914
2030	10767	37188	3454	2728	7176	2630	950	5784	6088

Source: Self calculation

for 2030 are 37188 thousand tons and 3454 kg ha^{-1}; 7176 thousand tons and 2630 kg ha^{-1} and 5784 thousand tons and 6088 kg ha^{-1}, respectively (Table 4).

The production would increase with increase in area/intensive farming, productive inputs like use of fertilizers, improved/certified seeds, irrigation water, improved cultivation method, mechanization, and treatment of soil (Figure 1).

The most important conclusion that emerges is that the production growth rate in respect of wheat, rice and maize crops in 2012 is higher than other years. While the production of wheat decelerated in 2030. The yield and production of wheat, rice and maize would be increased due to improvement in growing techniques. In rice the decrease in production occurred in 2014 while deceleration in maize would come in 2030. On average the growth rates of wheat, rice and maize crop in 2012-2030 accelerated @ 2.28%, 2.33% and 3.06%, respectively (Table 5).

The result of the study revealed that wheat, rice and maize produc-

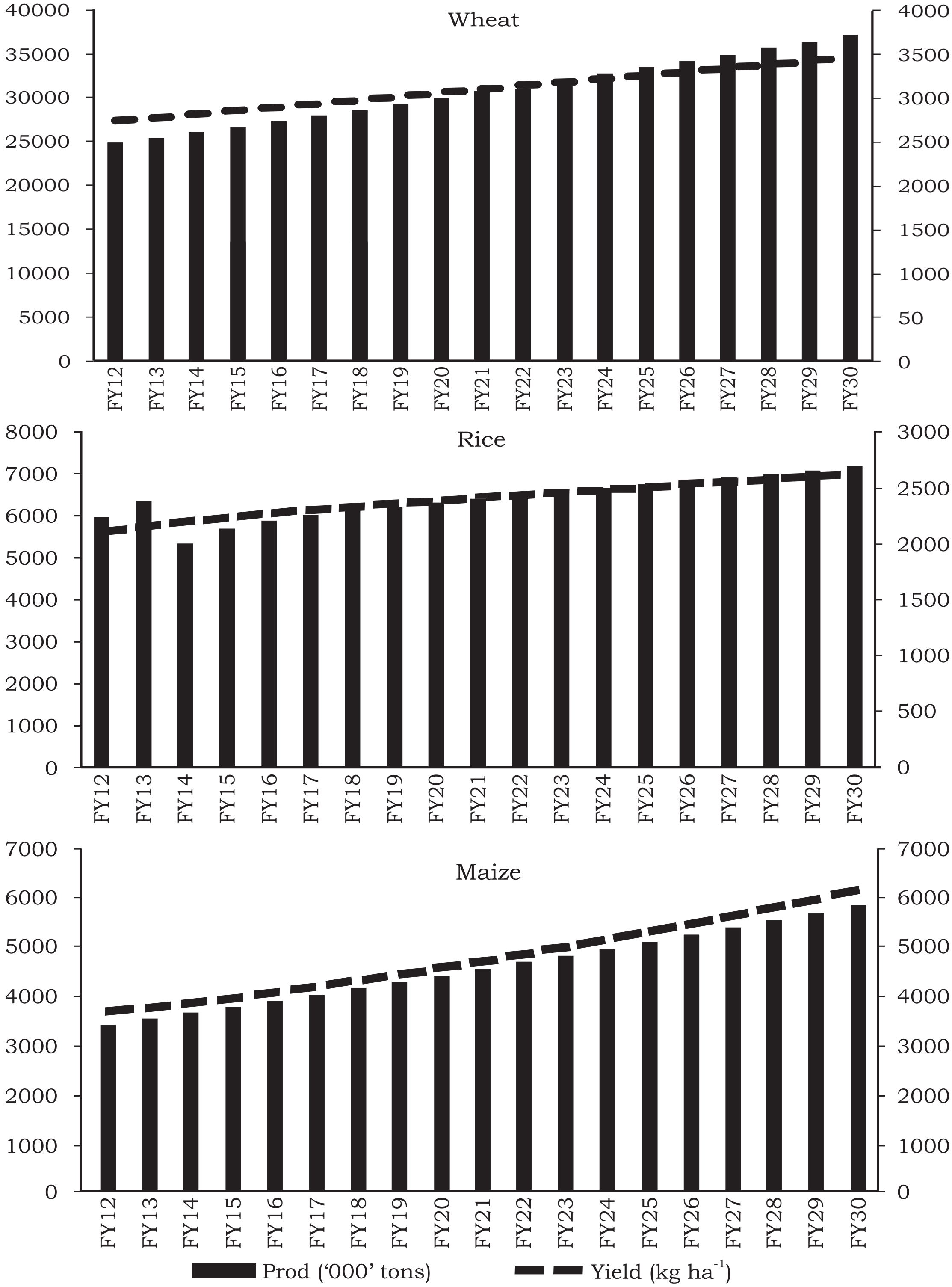

Figure 1. Forecast of food crops production and yield from 2012 to 2030

Table 5. Percentage of food crops production and yield forecast growth rate from 2012 to 2030

Year	Wheat		Rice		Maize	
	GP	GY	GP	GY	GP	GY
2012	2.86	-0.34	-23.76	3.08	3.68	2.21
2013	2.45	1.30	6.35	2.48	3.32	2.39
2014	2.43	1.44	15.95	2.06	3.41	2.55
2015	2.40	1.43	6.56	1.76	3.29	2.68
2016	2.38	1.40	3.52	1.55	3.28	2.78
2017	2.35	1.38	2.30	1.39	3.21	2.86
2018	2.33	1.36	1.78	1.28	3.17	2.92
2019	2.30	1.34	1.55	1.19	3.12	2.97
2020	2.28	1.32	1.44	1.13	3.08	3.00
2021	2.26	1.30	1.39	1.08	3.04	3.02
2022	2.24	1.29	1.35	1.04	2.99	3.04
2023	2.21	1.27	1.33	1.01	2.95	3.04
2024	2.19	1.25	1.31	0.99	2.91	3.04
2025	2.17	1.24	1.29	0.97	2.87	3.04
2026	2.15	1.22	1.27	0.96	2.84	3.02
2027	2.13	1.21	1.26	0.94	2.80	3.01
2028	2.11	1.19	1.24	0.93	2.76	2.99
2029	2.09	1.18	1.23	0.92	2.73	2.97
2030	2.07	1.16	1.21	0.91	2.69	2.95
Averages %	2.28	1.21	2.33	1.35	3.06	2.87

** Source: Self calculation; GP= Growth rate of production; GY= Growth rate of yield*

tion and yield for 2029-30 is 37188 thousand tons and 3454 kg ha^{-1}; is 7176 thousand tons and 2630 kg ha^{-1} and 5784 thousand tons and 6088 kg ha^{-1}, respectively. The production would be increased due to increase in area/intensive farming, productive inputs like use of fertilizers, improved/certified seeds, irrigation water, improved cultivation method, mechanization, and treatment of soil.

The higher production growth rate of wheat, rice and maize crops is recorded in 2012. The yield and production of wheat, rice and maize would be increased due to improvement in growing techniques. In rice the decrease in production occurred in 2014, while deceleration in maize would come in 2030. On average the growth rates of wheat, rice and maize crops from 2012 to 2030 accelerated @

2.28%, 2.33% and 3.06%, respectively.

LITERATURE CITED

Azhar, B.A., G.M. Chaudhary and M.A. Shafique. 1972. A model for forecasting wheat production in the Punjab. Pakistan Dev. Review , 11(2): 407-415.

Azhar, B.A., G.M. Chaudhry and M.A. Shafique. 1973. A model for forecasting wheat production in the Punjab. Q.J. PIDE XIV (1): 407-414.

Azhar, B.A., G.M. Chaudhary and M.A. Shafique. 1974. A forecast of wheat production in the Punjab for 1973-74. Pakistan Dev. Review, 13(1): 106-112.

Boken, V.K. 2000. Forecasting spring wheat yield using time series analysis: A case study for the Canadian prairies. Agric. J. 92 (6): 1047–1053.

Box, G. and G. Jenkins, 1976. Time series analysis: Forecasting and control, 2nd edn. Holden-Day, San Francisco.

Dickey, D.A. and W.A., Fuller. 1979. Distribution of the estimators for autoregressive time series with a unit-root. J. Amer. Static. Assoc. 74: 427-431.

GoP, 2011. Pakistan Economic Survey 2010-11. Ministry of Finance, Government of Pakistan, Islamabad. 15-33 p.

Hamid, N., P. Thomas, V. Alberto and G. Suzanne. 1987. The wheat economy of Pakistan setting and prospects. USAID/International Food Policy Research Institute, Washington, DC. (Mimeographed). 140 p.

Iqbal N., B. Khuda, M. Asif and S.A. Ahmad. 2005. Use of the ARIMA model for forecasting wheat area and production in Pakistan. J. Agric. and Social Sci. 1(2): 120-122.

Judge, G.G., R. Carter Hill, E.G. William and I. Helmut. 1988. Introduction to the theory and practice of econometrics. 2nd edn. John Wiley and Sons, INC. New York, Toronto, Singapore.

Muhammad, K. 1989. Description of the historical background of wheat improvement in Baluchistan, Pakistan (1909-1980). Rachis, 8: 10-12.

Muhammad, N. 2001. Factors affecting area and yield of wheat crop-A case study. Pakistan J. Agric. Econ. 4(2): 66-76.

Saeed, N., A. Saeed, M. Zakria, and T.M. Bajwa. 2000. Forecasting of wheat production in Pakistan using ARIMA models. Intern. J. Agric. Bio. 2(4): 352–353.

Salam, A.M., S. Salam and M. Feridun. 2006. Forecasting Inflation in Developing Nations: The case of Pakistan. Int. Res. J. Finance Econ. 3:138-159.

Shabur, S.A. and M.E. Haque. 1993. An analysis of rice price in Mymensing town market pattern and forecasting. Bangladesh J. Agric. Econ. 16(2): 61-75.

Sohail, A., A. Sarwar and M. Kamran. 1994. Forecasting total food grains in Pakistan. J. Engg. Appl. Sci. 13(2): 99-103,

Yaseen, M., M. Zakria, Islam-ud-din-Shahzad, M.I. Khan, and M.A. Javed. 2005. Modeling and forecasting the sugarcane yield of Pakistan. Intern. J. Agric. Bio. 7(2): 180–183.

AUTHORSHIP AND CONTRIBUTION DECLARATION

S. No	Author Name	Contribution to the paper
1.	Mr. Nouman Badar	Conceived idea, Wrote abstract Methodology, Did review analysis and Result and discussion
2.	Ms. Hina Fatima	Data collection, Data entry, Introduction and references
3.	Dr. Abdul Jabbar	Technical input at every step and overall management of paper
4.	Dr. Muhammad Asif	Technical input at every step

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