# “FORECASTING RICE PRODUCTION IN BANGLADESH USING STATISTICAL MODEL”

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## Outline of the presentation

- ❖Background
- ❖Rationale
- ❖Objectives
- ❖Statistical Methodology
  - ➢Data
  - ➢Statistical Data Analysis
- ❖Findings
- ❖Conclusion

# Background

- High production and demand of Rice
- Food Policy Making for interim period
- Preparing Provisional GDP
- Crop Monitoring in general term

# Rationale

Forecasting plays vital role in decision making at all levels of the economy.

- ✓ Production forecast can be helpful for the market decision maker to making policy for market stability.
- ✓ Forecasting of rice production is necessary due to improving food policy and monitoring the food system.
- ✓ Export potentiality can be evaluated after forecasting rice production.
- ✓ Forecasting is essential for measuring the exact contribution of the rice cultivation towards the national account (provisional GDP).

# Objectives of the study

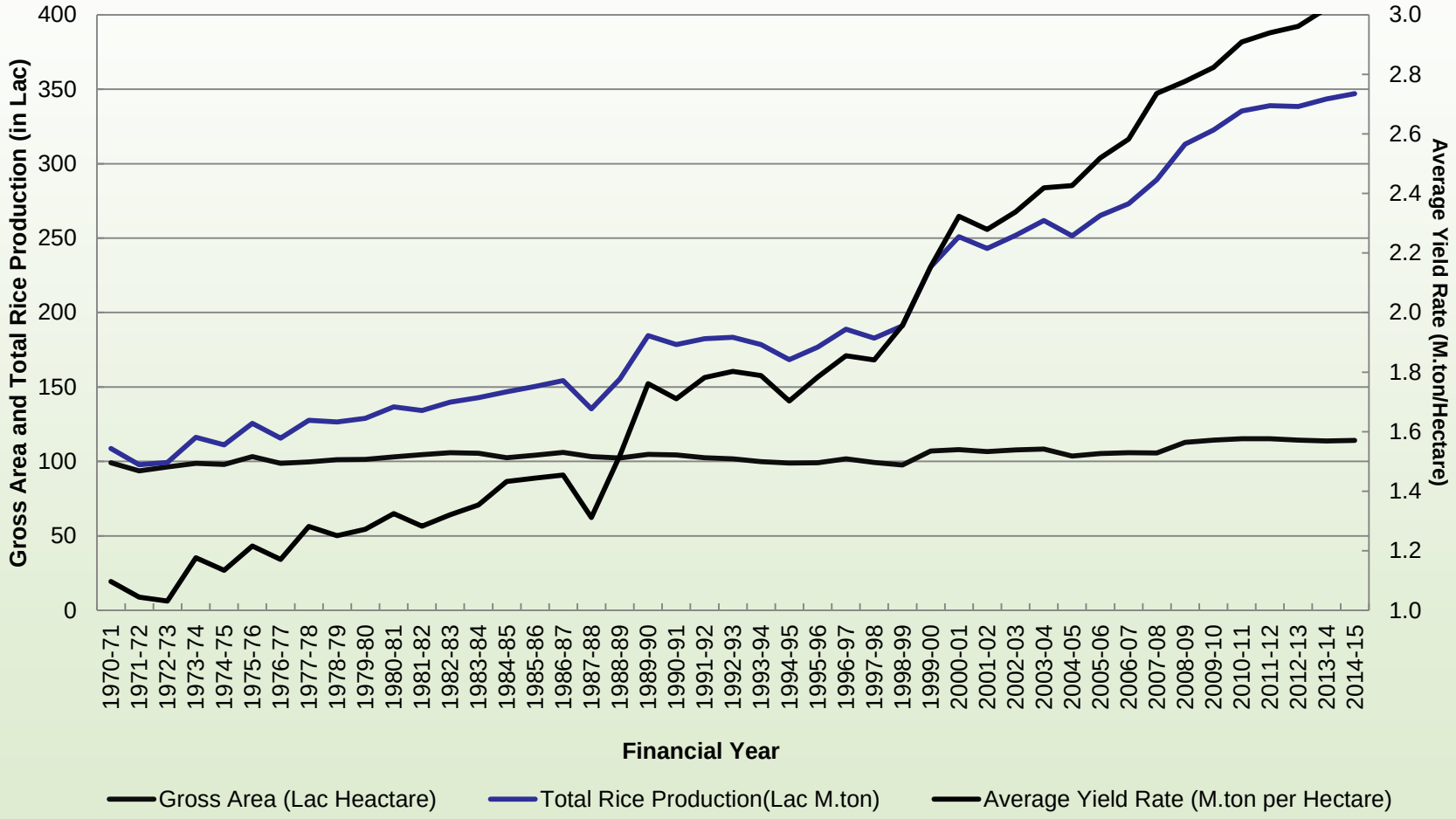
The specific objectives of the current study are -

i) To evaluate the trend of rice production in Bangladesh;

ii)To develop time series and mixed models for forecasting AMAN, Boro, and AUS rice production;

iii) To make forecasts with appropriate prediction interval after comparing the forecasting performance of different time series and mixed models.

# Figure 1: Trend comparison among gross area, total rice production and average yield rate



# Availability of Time series data for Modeling

- Yearly production statistics, Are, Yield and Production-BBS
- Monthly/daily average temperature-BMD
- Monthly/daily average rainfall-BMD
- Farm gate level price of price-DAM
- Irrigation data (not usable)
- Fertilized data (not useful)

# Statistical Methods

**Pure time series:** The Box-Jenkins methodology can be applied to fit best autoregressive integrated moving average (ARIMA) model for time series forecasting. The method consists of three phases-

Phase 1: Pattern analysis and data preparation

Phase 2: Estimation and testing

Phase 3: Forecasting

**Mixed-model approach:** Mixed model approach is one of the dynamic regressions modeling which can be applied to identify the role of explanatory variables in determining the variable of interest (dependent variable).

# Statistical Methods

## Pure time series model:

$$\Delta^d Production_t = \alpha_0 + \sum \alpha_p Production_{t-p} + \sum \lambda_q Eroor_{t-q} + + Error_t$$

*Where,* $\Delta$ refers the differencing of the time series. P, d and q are the order of autoregressive, differencing and moving average.

## Mixed time series model:

$$\Delta^d Production_t = \alpha_0 + \sum \alpha_p Production_{t-p} + \sum \beta_i Area_{t-i} + \sum \lambda_q Eroor_{t-q} + Error_t$$

*Where,* $\beta_i$ *is the ith coefficient of the lagged explanatory (independent) variables whereas* $\alpha_p$ *is the pth coefficient of lagged dependent variable and* $\alpha_0$ *is the constant.*

## Findings

- The stationarity of total rice production (in Lac Metric tons) of Aman, Boro, and Aus rice from financial year 1992-93 to 2014-15 have been checked on the basis of Augmented Dickey –Fuller and Phillips-Perron test.

- At first difference, Aman, Boro, and Aus rice production in different year's data are stationary (table 1) which is important for next step of forecasting.

Table 1: The stationarity checking of rice production in Lac M.ton (from1992-93 to 2014-15)

| Rice variety | Difference | Augmented Dickey – Fuller test | | Phillips-Perron test | | Comment |
|---|---|---|---|---|---|---|
| | | Statistic | P-value | Statistic | P-value | |
| **AMAN** | No | 0.504 | 0.8164 | 1.691 | 0.973 | Not stationary |
| | First | -5.140 | 0.000 | -5.431 | 0.000 | Stationary |
| **AUS** | No | 0.840 | 0.884 | 0.192 | 0.732 | Not stationary |
| | First | -2.058 | 0.041 | -6.585 | 0.000 | Stationary |
| **BORO** | No | 3.159 | 0.999 | 2.916 | 0.998 | Not stationary |
| | First | -2.717 | 0.009 | -2.641 | 0.011 | Stationary |

# Table 2: Model selection criteria for checking the best fitted model

| Rice variety | Model | $R^2$ | RMSE | MAPE | BIC | Ljung-Box Q | |
|---|---|---|---|---|---|---|---|
| | | | | | | Statistic | P-value |
| AMAN | ARIMA(2,1,0) | 0.686 | 10.026 | 7.375 | 10.026 | 15.010 | 0.524 |
| | Mixed-model | 0.958 | 3.808 | 2.705 | 3.254 | 17.199 | 0.441 |
| AUS | ARIMA(2,1,1) | 0.563 | 1.815 | 7.586 | 1.754 | 18.375 | 0.244 |
| | Mixed-model | 0.878 | 1.018 | 3.974 | 0.760 | 8.407 | 0.936 |
| BORO | ARIMA(1,2,0) | 0.960 | 8.987 | 4.603 | 4.68 | 12.762 | 0.752 |
| | Mixed-model | 0.993 | 3.975 | 2.269 | 3.340 | 13.657 | 0.691 |

# Findings

- The best model can be find out on the basis of maximum value of $R^2$ and minimum value of root mean squared error (RMSE), mean absolute percent error (MAPE), Bayesian information criterion (BIC) where Ljung-Box test reveals that the residuals follows white noise.

- Here, the mixed-model is the best fitted model for forecasting Aman, Boro, and Aus rice production on the basis of different model selection criteria

# Table 3: Forecast production of AMAN rice (in lac M.ton) from the financial year 2015-16 to 2020-21

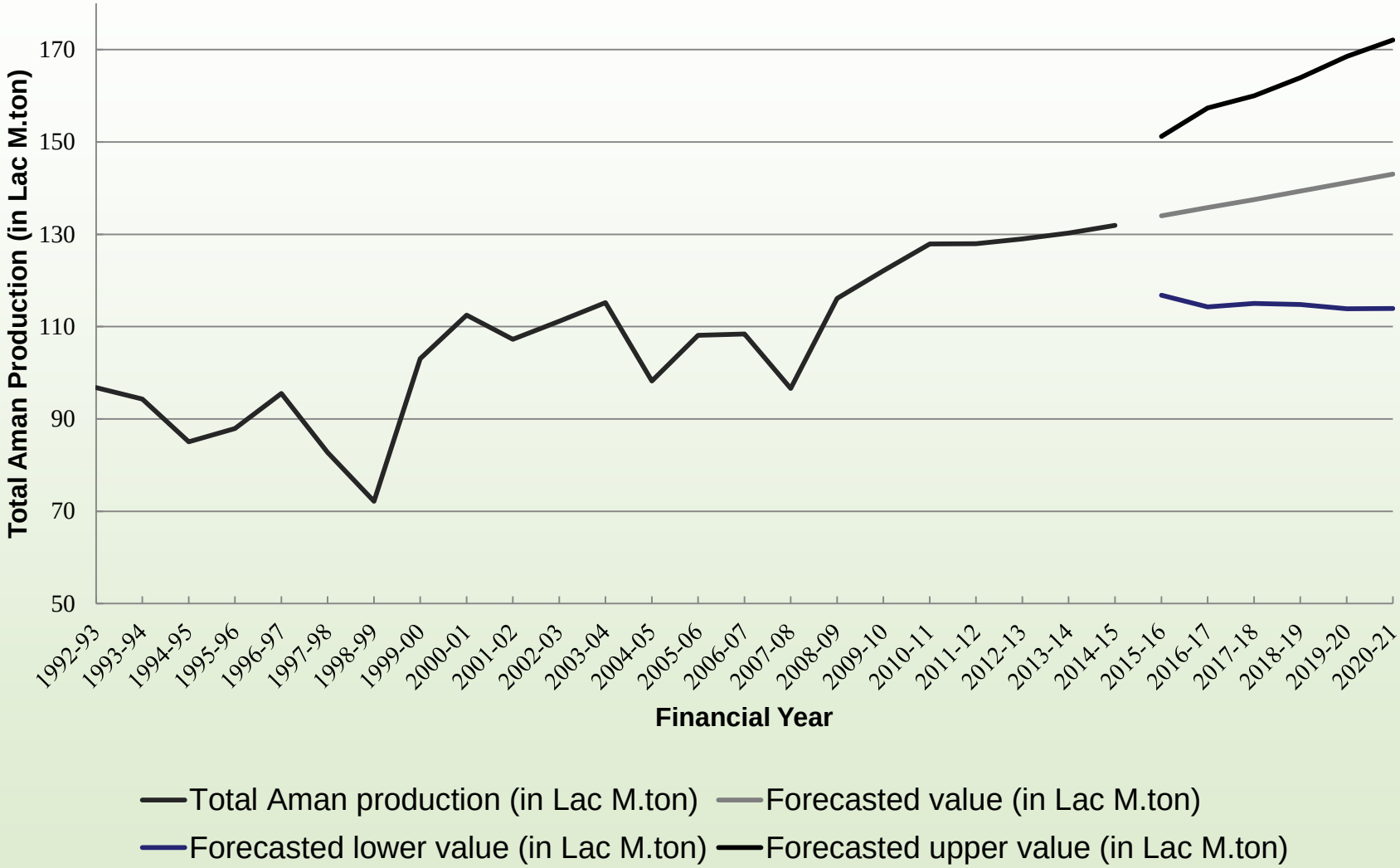
| Financial year | ARIMA(2,1,0) | | | Mixed-model | | |
|---|---|---|---|---|---|---|
| | Forecast | Lower limit | Upper limit | Forecast | Lower limit | Upper limit |
| 2015-16 | 133.998 | 123.972 | 144.024 | 136.483 | 132.675 | 140.291 |
| 2016-17 | 135.810 | 125.784 | 145.836 | 140.647 | 136.838 | 144.454 |
| 2017-18 | 137.503 | 127.477 | 147.529 | 143.659 | 139.851 | 147.467 |
| 2018-19 | 139.350 | 129.324 | 149.376 | 146.520 | 142.712 | 150.328 |
| 2019-20 | 141.212 | 131.186 | 151.238 | 149.338 | 145.530 | 153.146 |
| 2020-21 | 143.003 | 132.977 | 153.029 | 152.052 | 148.244 | 155.860 |

❖ The equations to construct forecast limit are-

Upper Limit= Forecast value + $(\text{Mean Square Error})^{1/2}$

Lower Limit= Forecast value - $(\text{Mean Square Error})^{1/2}$

# Forecast Aman Rice Production by ARIMA(2,1,0)



# Forecast Aman Rice Production by Mixed model

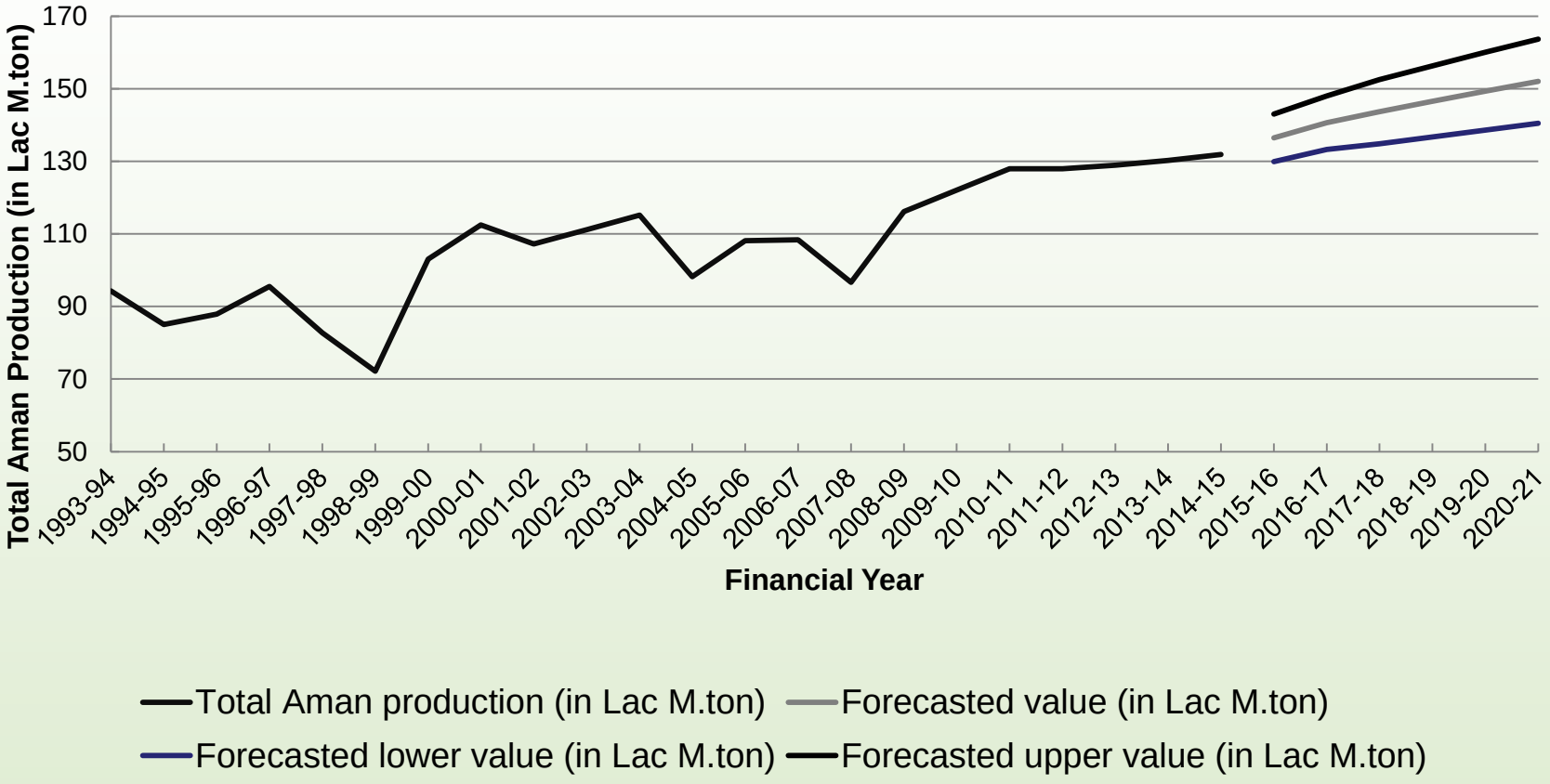
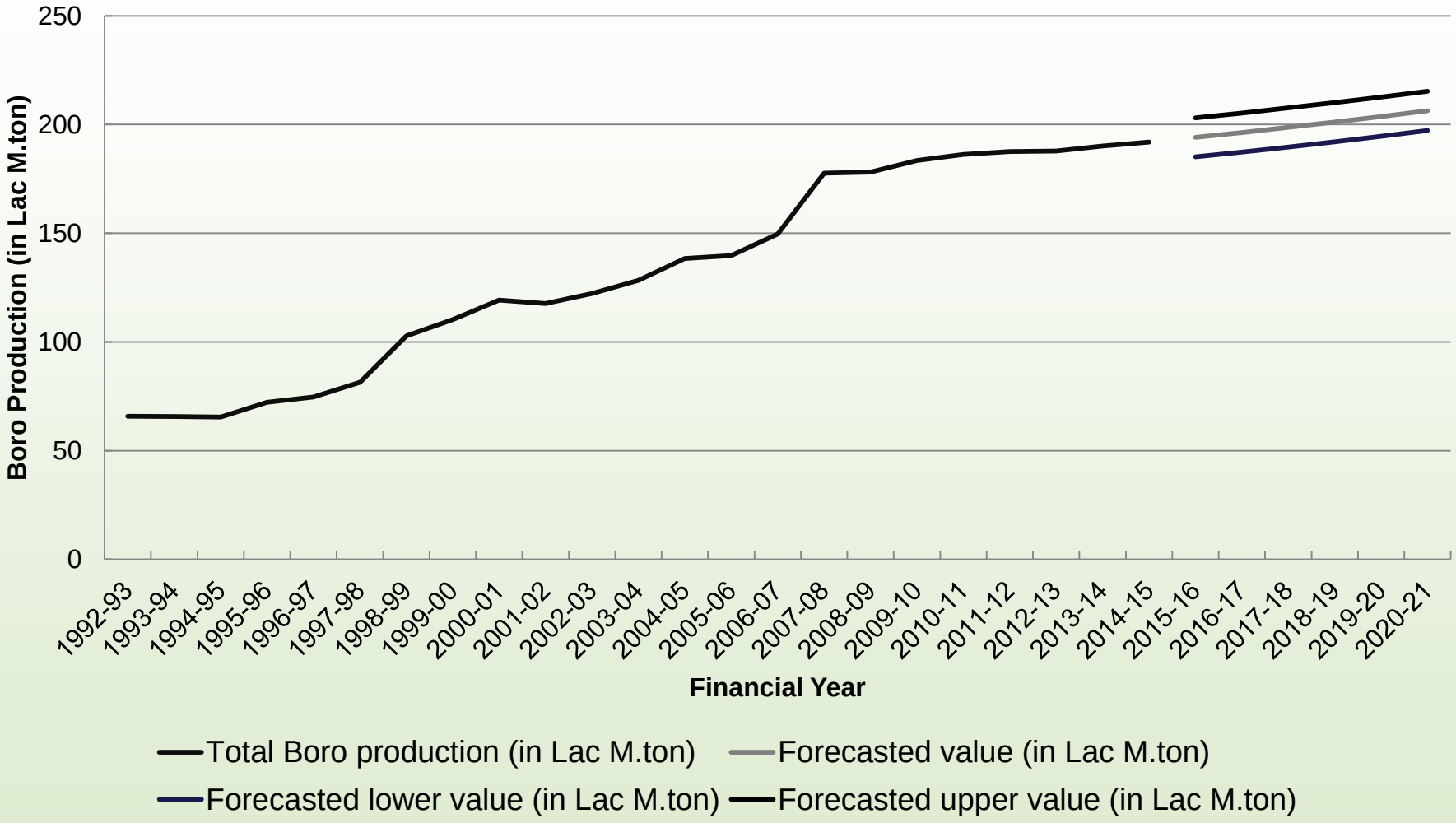


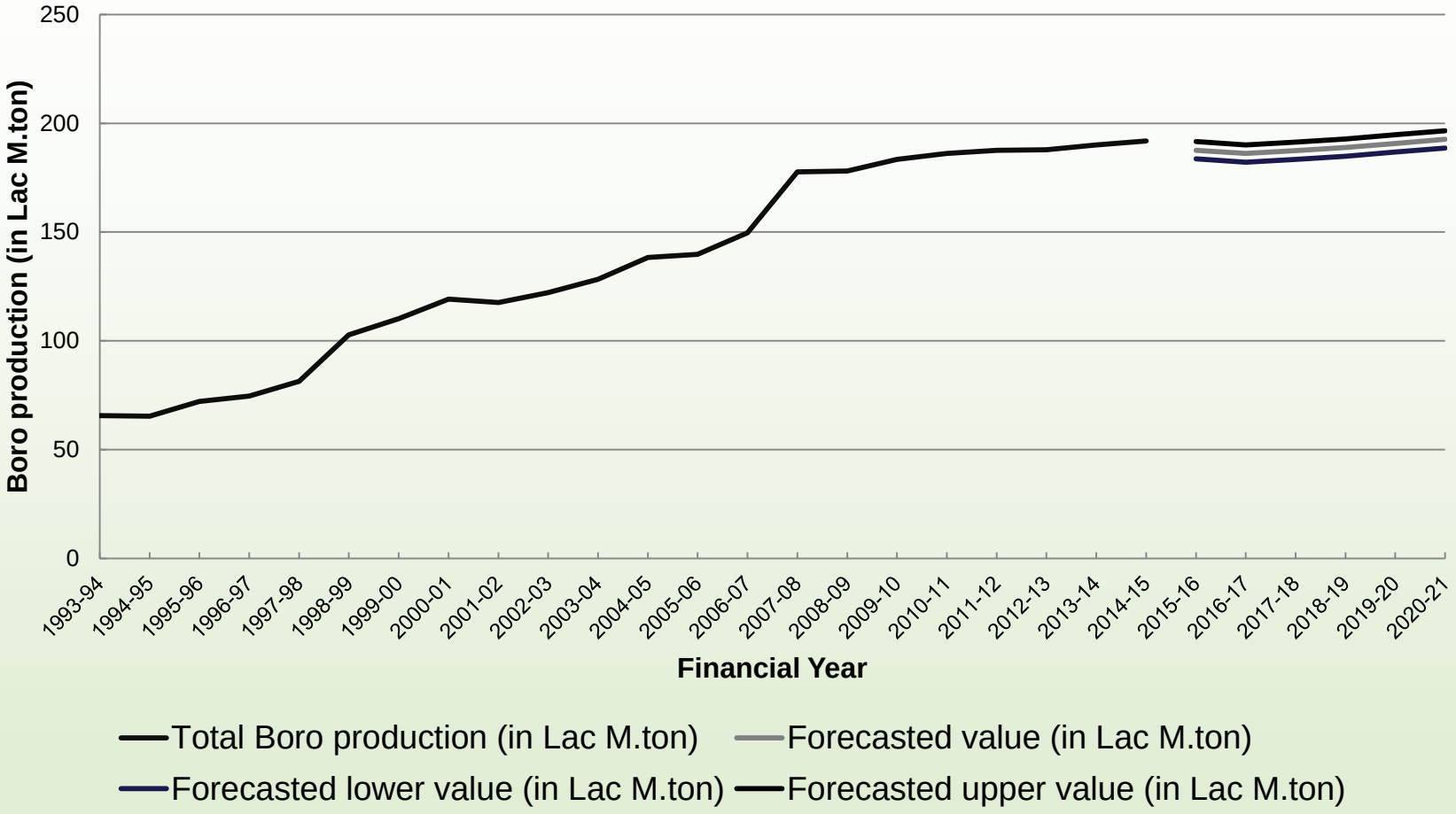
Table 4: Forecast production of BORO rice (in lac M.ton) from the financial year 2015-16 to 2020-21

| Financial year | ARIMA(1,2,0) | | | Mixed-model | | |
|---|---|---|---|---|---|---|
| | Forecast | Lower limit | Upper limit | Forecast | Lower limit | Upper limit |
| 2015-16 | 194.112 | 185.125 | 203.099 | 187.613 | 183.638 | 191.588 |
| 2016-17 | 196.307 | 187.320 | 205.294 | 186.125 | 182.150 | 190.100 |
| 2017-18 | 198.652 | 189.665 | 207.639 | 187.415 | 183.440 | 191.390 |
| 2018-19 | 201.084 | 192.097 | 210.071 | 188.819 | 184.844 | 192.794 |
| 2019-20 | 203.630 | 194.643 | 212.617 | 190.740 | 186.765 | 194.715 |
| 2020-21 | 206.278 | 197.291 | 215.265 | 192.604 | 188.629 | 196.579 |

# Forecast Boro Rice Production by ARIMA(1,2,0)



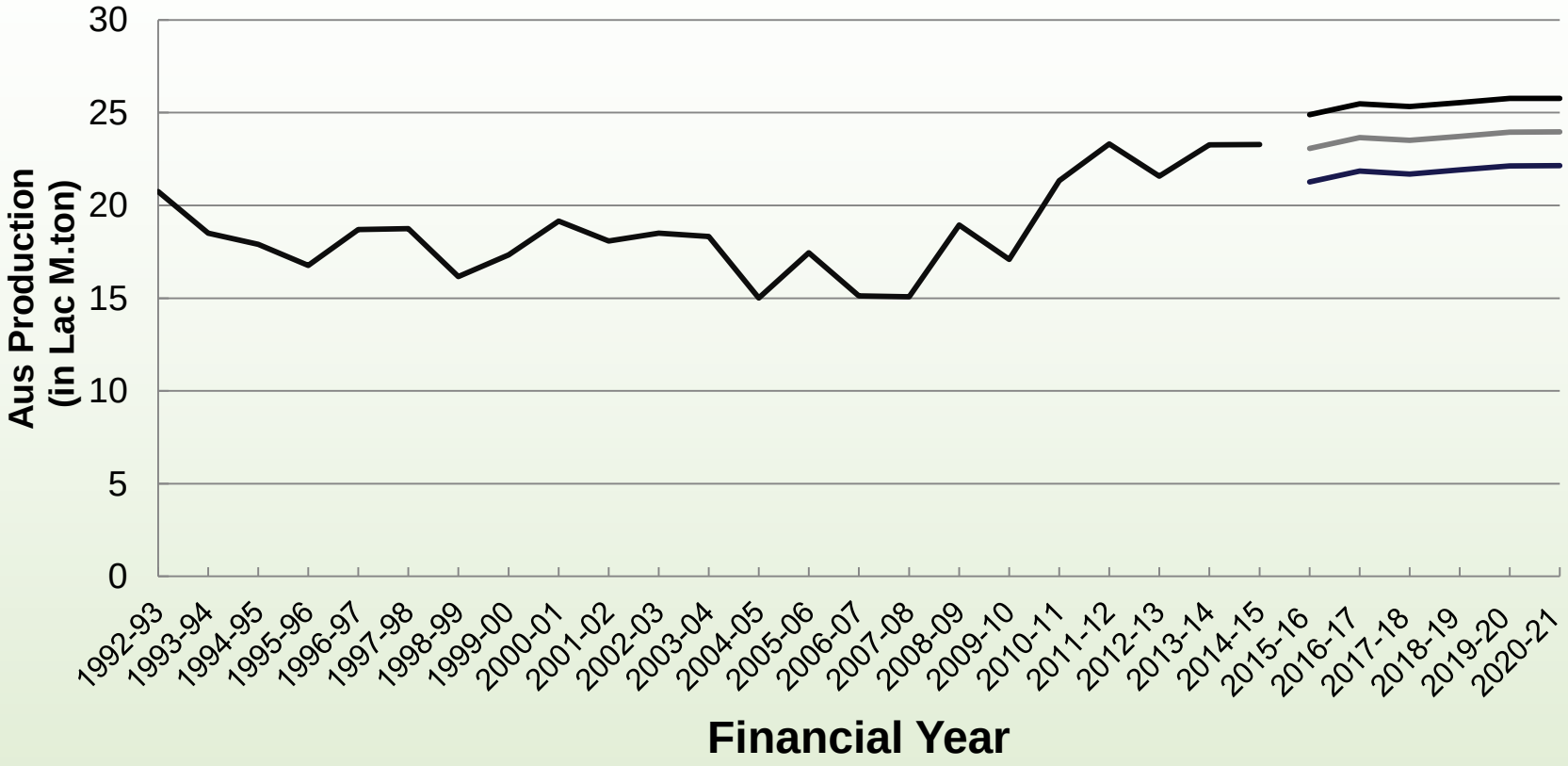
# Forecast Boro Rice Production by Mixed model



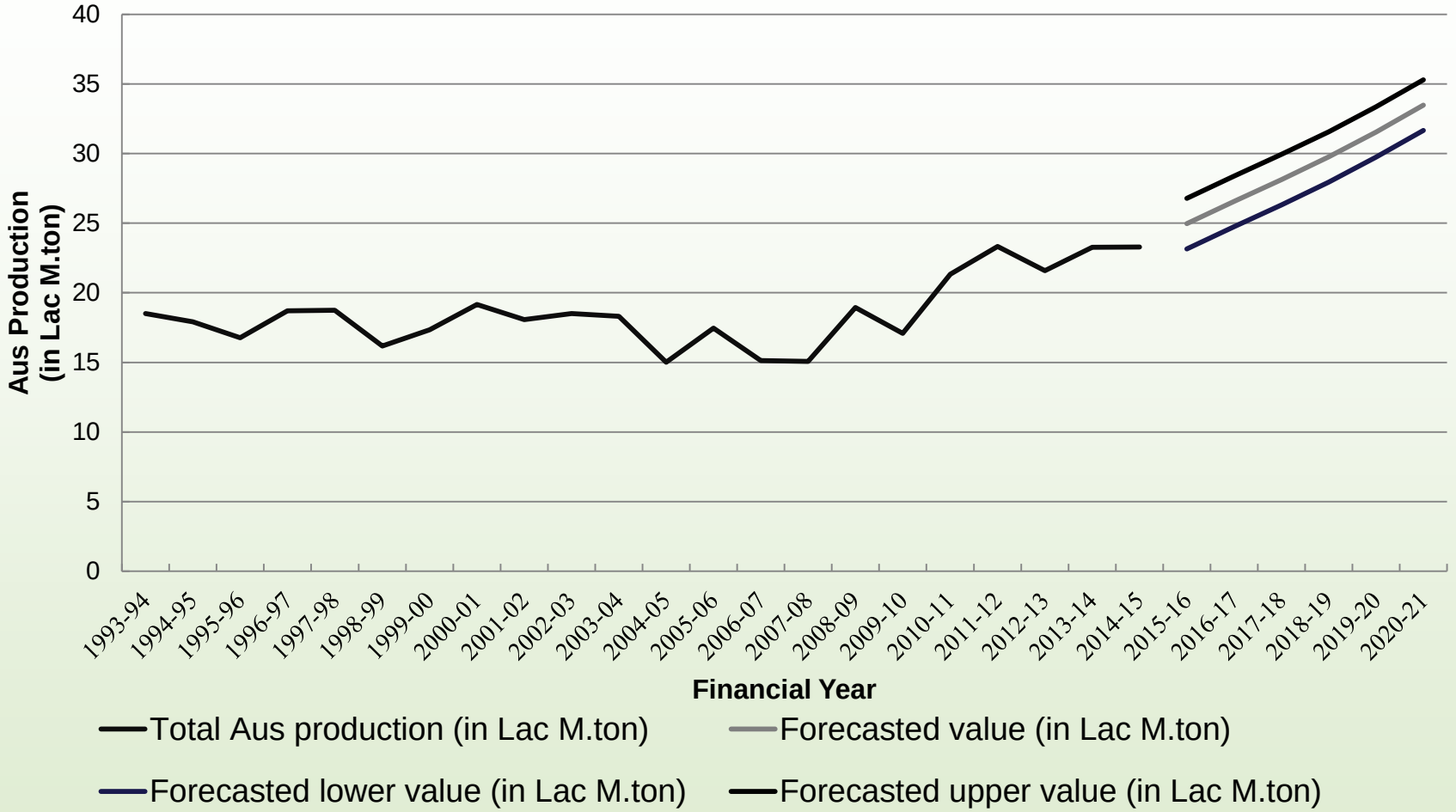
# Table 5: Forecast production of AUS rice (in Lac M.ton) from the financial year 2015-16 to 2020-21

| Financial year | ARIMA(2,1,1) | | | Mixed-model | | |
|---|---|---|---|---|---|---|
| | Forecast | Lower limit | Upper limit | Forecast | Lower limit | Upper limit |
| 2015-16 | 23.077 | 21.262 | 24.892 | 24.9703 | 23.1553 | 26.7853 |
| 2016-17 | 23.665 | 21.850 | 25.480 | 26.5618 | 24.7468 | 28.3768 |
| 2017-18 | 23.510 | 21.695 | 25.325 | 28.1191 | 26.3041 | 29.9341 |
| 2018-19 | 23.726 | 21.911 | 25.541 | 29.7565 | 27.9415 | 31.5715 |
| 2019-20 | 23.950 | 22.135 | 25.765 | 31.5534 | 29.7384 | 33.3684 |
| 2020-21 | 23.959 | 22.144 | 25.774 | 33.4769 | 31.6619 | 35.2919 |

# Forecast Aus Rice Production by ARIMA(2,1,1)



# Forecast Aus Rice Production by Mixed model



# Table 6: Forecast total rice production (in Lac M.ton) from the financial year 2015-16 to 2020-21

| Financial Year | ARIMA | | | | Mixed Model | | | |
|---|---|---|---|---|---|---|---|---|
| | Aman | Boro | Aus | Total | Aman | Boro | Aus | Total |
| 2015-16 | 133.998 | 194.112 | 23.077 | 351.19 | 136.483 | 187.613 | 24.97 | 349.07 |
| 2016-17 | 135.81 | 196.307 | 23.665 | 355.78 | 140.647 | 186.125 | 26.562 | 353.33 |
| 2017-18 | 137.503 | 198.652 | 23.51 | 359.67 | 143.659 | 187.415 | 28.119 | 359.19 |
| 2018-19 | 139.35 | 201.084 | 23.726 | 364.16 | 146.52 | 188.819 | 29.757 | 365.10 |
| 2019-20 | 141.212 | 203.63 | 23.95 | 368.79 | 149.338 | 190.74 | 31.553 | 371.63 |
| 2020-21 | 143.003 | 206.278 | 23.959 | 373.24 | 152.052 | 192.604 | 33.477 | 378.13 |

- Forecasted total rice production for financial year 2015-16 by ARIMA or mixed model is almost equal to the projection of the national level.

# Conclusion

- ✓ The forecasting performance of mixed-model is better than the other ARIMA model.
- ✓ Forecasted value of total rice production for financial year 2015-2016 (summation of Aman, Boro, and Aus rice) is almost similar with national projection.
- ✓ Predictions so far conform to national policy projection 2021.
- ✓ Still now, the production level of Boro rice is higher than others.

# Conclusion (Contd.)

- Before publishing official statistics, internal validation of the model should be needed to adjust the forecasted value.

- Small sample will be drawn from upazilla for surveying farmers' prediction about current year production by BBS office and the ratio estimate of the production will be identified for adjusting forecast value.

# Conclusion (contd.)

- Model need to be verified and reconstruct after few years to account the structural change due to some unavoidable circumstances.

- Along with the statistical model, other available technology especially agro-met based yield modeling and remote sensing should be used for final forecast.

Thank You