

TIME SERIES MODELLING AND FORECASTING OF PRICES OF CATTLE FEED IN TAMIL NADU

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ABSTRACT

The quantum of inclusion of concentrates in cattle feeding depends solely on availability and its price. An attempt was made to model and forecast the feed prices of dairy cattle feed in Tamil Nadu using time series data collected from Central Feed Technology Unit, Kattupakkam for the period from January 2012 to December 2022. Various time series models viz., Mean, Naïve, Random drift, Seasonal naive, Simple Exponential Smoothing, Holt linear, Holt-winter, Autoregressive Integrated Moving Average - ARIMA and Seasonal Autoregressive Integrated Moving Average models were fitted. The error measures, parameter estimates, forecast estimates and plots were assessed to ascertain the best fit model. Random drift model and ARIMA (0,1,0) model were found to be the best fit models for dairy cattle feed. Further, Holt-winter multiplicative model and SARIMA (1,1,0)(1,0,1) model were identified as the best fit models for the dry cattle feed price forecasting. Thus, these models could be utilized by the various stakeholders to predict the short term price forecasts of cattle feed for efficient planning and making right decisions.

Key words: ARIMA – Cattle –Feed prices – Forecasting – Time series model

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INTRODUCTION

The dairy production systems in India are complex and generally based on traditional and socio-economic considerations mainly guided by available feed resources. The scarcity of feed and fodder resources (both quantity and quality) primarily affect the nutrition in animals, which would impair the production performance (Misra, 2019) and thus balanced feeding of dairy cattle is crucial for profitable dairy farming. Feed cost occupies major share in the total cost of dairy farming all over the world including India (George *et al.*, 2021; Akter *et al.*, 2023). The prices of the feed / fodder have negative effect on profitability (Thakur *et al.*, 2018). The quantum of inclusion of concentrates in dairy cattle feeding depends solely on availability and its price. The prices of compound feed depend on the prices of its raw materials / feed ingredients and cost of production. Further, these feed prices vary with the components of trend, seasonal, cyclical and irregular components. In this context, an attempt was made to model and forecast the feed prices of dairy cattle feed using time series data.

METHODOLOGY

The time series data on market prices (monthly average) of compound feed mix of cattle (milch and dry cattle feed) for the period from January 2012 to December 2022 were collected from Central Feed Technology Unit, Kattupakkam which is a constituent unit of Tamil Nadu Veterinary and Animal Sciences University. Twelve months centered moving average was used for smoothing the data series and ascertaining the trend of the data.

Average values of order 'k' (12 months) were calculated and obtained results corresponds to the middle of the considered period and continued till completion of the data series. Mann-Kendall trend test (Aswad *et al.*, 2020), Coxstuart (cma) test (Rutkowska, 2015), Sen's slope (Aswad *et al.*, 2020), Friedman (Non-parametric) test (Davey and Flores, 1993) and Augmented Dickey-Fuller test were performed to ascertain the nature of data for further data analysis. Various time series models viz., Mean, Naïve, Random drift, Seasonal naïve, Simple Exponential Smoothing, Holtlinear, Holt-winter, Autoregressive Integrated Moving Average - ARIMA and Seasonal Autoregressive Integrated Moving Average (SARIMA) models were fitted.

The data on prices for the period January 2012 to December 2021 were considered as Training set and the remaining data for the period January 2022 to December 2022 were considered as test set in order to assess the accuracy of prediction. The analysis was performed using R studio version 4.2.2. The models were fitted without violating the assumptions of mentioned models. After considering the error measures of each model and comparison of forecast estimate with the actual test data, best fit model for forecasting the prices of dairy cattle feed and dry cattle feed in Tamil Nadu.

RESULTS AND DISCUSSION

Based on the Centred Moving Average and Seasonal box plots of feed prices of milch and dry cattle in Tamil Nadu for the period from 2012 to 2022, it is evident that the median of feed prices of dairy cattle was found to be

the lowest during the month of January and the highest during the month of July. The prices of dairy cattle feed were above the index value of 100 from the months of April to September, and during the rest of months, the index values were observed to be below 100. Similarly the index values were found to be less than 100 for the period of January to March for dry cattle feed prices in Tamil Nadu. Later, the index values were found to be above 100 for the period from April to December except during the months of November and May.

As shown in Table 2, the parameter values of Mann-Kendall Trend test implied the presence of trend component for both milch and dry cattle feed prices in Tamil Nadu and the magnitude of trend per month was estimated to increase by Rs. 0.0579 for Milch cattle feed and Rs. 0.0461 for dry cattle feed. Further, the parameters of Cox-stuart test and Friedman test revealed the presence of seasonality in feed prices of milch and dry cattle feed in Tamil Nadu. The p-values of Augmented Dickey-Fuller test indicated that the data series of milch cattle feed prices were found to be non-stationary, whereas it was stationary in case of dry cattle feed prices.

From the Table 3, it could be inferred that the AIC, AICc and BIC values were found to be minimum for the ARIMA (0,1,0) model for milch cattle feed prices and SARIMA (1,1,0) (1,0,1) model for dry cattle feed prices. The time series models viz., Simple Exponential Smoothing, Holt linear and Holt-winter Multiplicative models had higher values of AIC, AICc and BIC, which indicated that the mentioned models were not the best fit models.

Various time series models viz., Mean, Naive, Random drift, Seasonal naive, Simple Exponential Smoothing, Holtlinear, Holt-winter, ARIMA / SARIMA were fitted for the feed prices of milch cattle and dry cattle. The error parameters of the fitted models of feed prices of milch and dry cattle are presented in Table 4. Among the various time series models of dairy cattle feed prices, the error measures viz., Mean Error (ME), Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), Mean Absolute Scaled Error (MASE) were found to be the highest for Mean model, followed by the Seasonal naïve and Naïve models. The Mean Absolute Percentage Error was found to be the lowest for ARIMA model (3.4514), followed by the Random drift model (3.8572) for milch cattle feed prices. Thus, based on the accuracy measures, ARIMA model was observed to be the most accurate (96.55 per cent), followed by the Random drift model (96.14 per cent).

Among the various models fitted for dry cattle feed prices, error measures were found to be the highest for Mean model and the lowest for the Holt-winter model. The MAPE was found to be more than five for all the model except for the Holt-winter and ARIMA models and thus the Holt-winter model was estimated to be the most accurate (96.77 per cent), followed by the ARIMA model (96.19 per cent). For the milch cattle feed prices, best fit ARIMA model was estimated as ARIMA (0,1,0). For the dry cattle feed prices, best fit ARIMA model was found to be SARIMA (1,1,0) (1,0,1).

Table 1. Time series models fitted for forecasting the prices of cattle feed

S. No.	Time series Models	Model description	Reference
1	Mean	$\hat{y}_{T+h} = \bar{y}$	Hyndman and Athanasopoulos, (2018)
2	Naive	$\hat{y}_{T+h} = y_T$	Hyndman and Athanasopoulos, (2018) Naim and Mahara, (2018)
3	Seasonal naive	$\hat{y}_{T+h} = y_{T+h-m(k+1)}$	Hyndman and Athanasopoulos, (2018)
4	Drift	$\hat{y}_{T+h} = y_T + h \left[\frac{y_T - y_1}{T - 1} \right]$	Hyndman and Athanasopoulos, (2018) Naim and Mahara, (2018)
5	Simple Exponential Smoothing	$\hat{y}_{T+1} = \alpha y_T + \alpha(1-\alpha)y_{T-1} + \alpha(1-\alpha)^2 y_{T-2} \dots$ <i>where $0 \leq \alpha \leq 1$</i>	Meera and Sharma, (2017)
6	Holt linear	$\hat{y}_{T+h} = l_t + h b_t$ $l_t = \alpha y_t + (1-\alpha)(l_{t-1} + b_{t-1})$ $b_t = \beta * (l_t - l_{t-1}) + (1-\beta) b_{t-1}$ <i>where $0 \leq \alpha \leq 1$ and $0 \leq \beta \leq 1$</i>	Suraiya and Hasan, (2018)
7	Holt winters' seasonal Multiplicative	$\hat{y}_{T+h} = (l_t + h b_t) s_{t+h-m(k+1)}$ $l_t = \alpha \frac{y_t}{s_{t-m}} + (1-\alpha)(l_{t-1} + b_{t-1})$ $b_t = \beta * (l_t - l_{t-1}) + (1-\beta) b_{t-1}$ $s_t = \gamma \frac{y_t}{(l_{t-1} + b_{t-1})} + (1-\gamma) s_{t-m}$ <i>where $0 \leq \gamma \leq 1 - \alpha$</i>	Holt, (1957) and Winters, (1960)
8	ARIMA (p,d,q)	$y'_t = c + \phi_1 y'_{t-1} + \dots + \phi_p y'_{t-p} + \theta_1 \varepsilon_{t-1} + \dots + \theta_q \varepsilon_{t-q} + \varepsilon_t$ <i>y'_t is the differenced series</i> p- order of the autoregressive part d- degree of first differencing q-order of moving average part	Jha and Sinha, (2013); Areef <i>et al.</i> (2020); Kumar <i>et al.</i> (2021); Goyal <i>et al.</i> (2021) and Badal <i>et al.</i> (2022)
9	SARIMA (p,d,q) (P,D,Q) ₁₂	$(1 - \phi_1 B)(1 - \phi_1 B_{12})(1 - B)(1 - B_{12})y_t = (1 + \theta_1 B)(1 + \theta_1 B_{12})\varepsilon_t$	Reddy, (2019); Udayshankar and Raghavender, (2020); Badal <i>et al.</i> (2022)

Table 2. Tests for presence of trend, seasonality and stationary

Tests	Milch cattle feed prices	Dry cattle feed prices
Mann-Kendall Trend Test	Z = 8.5139 p-value = 2.2e-16**	Z = 8.2188 p-value = 2.2e-16**
Coxstuart (cma) test	p-value = 1.355253e-20**	p-value = 1.355253e-20**
Sen's slope	0.05797101	0.04615385
Friedman test (Non-parametric)	P<0.002**	P=0**
Augmented Dickey-Fuller Test	Dickey-Fuller = -3.1593 Lag order = 5 p-value = 0.09776**	Dickey-Fuller = -3.4914 Lag order = 5 p-value = 0.04587**

** - Significant at one per cent level

The prices of milch cattle feed and dry cattle feed in Tamil Nadu were forecasted using fitted models for the period of January 2022 to December 2022 and it was compared with the actual test data and the results are portrayed in Table 5. It could be inferred from the table that the actual price of milch cattle feed was Rs. 28 for the months of June and July 2022; Rs. 29 for the months of January, March, April, May and August 2022; Rs. 30 for the month of October 2022 and Rs. 31 for the months of February, September, November and December 2022. For the same period, the forecasted estimates of milch cattle feed prices were noticed to be gradually increasing from January 2022 (Rs.28.10) to December 2022 (Rs.29.16) with an approximate increase of Re. 0.10 every month. In contrast, the best fit ARIMA (0,1,0) model forecasted the for the milch cattle feed as Rs. 28 throughout the test data period from January 2022 to December 2022. Although Naïve models (Rs. 28.00), SES model (Rs.27.91) and Holt linear model (Rs.27.88) predicted the price closely to the actual prices, these models were not considered as best fit models considering the values of the error measures.

As shown in Table 5, the actual price of dry cattle feed was Rs. 22 during the month of January 2022 and gradually increased Rs. 24 (February 2022) and Rs. 25 (March to May 2022). Later there was a dip during June 2022 (Rs.24) and started increasing till September 2022 (Rs. 28). Again there was a decrease in price of dry cattle feed during the months of October and November 2022 (Rs. 27) and finally raised upto Rs. 28 during the month of December 2022. Among the models fitted for Dry cattle feed prices, Holt-winter model forecasted dry cattle feed prices as Rs.22.75 for the month of January 2022 and gradually increased to Rs.25.78 up to the month of June 2022 with the increase in magnitude of approximately Re. 0.4 to Re. 0.5. Later there was small hike of Rs. 1.36 in the price of dry cattle feed during the month of July 2022 (Rs. 27.14), followed by a dip during August 2022 (Rs. 26.63); hike during September (Rs. 27.30); dip during October 2022 (Rs. 26.85) and November 2022 (Rs. 26.61). The prediction estimate of dry cattle feed price for Holt-winter model was observed to be Rs. 26.82 for the month of December against the actual price of Rs. 28. On the other hand, best

Table 3. Estimated parameters of time series models for cattle feed prices

Models	Parameters	Feed prices	
		Milch cattle	Dry cattle
Simple exponential smoothing (ETS)	alpha	0.8953	0.8061
	Initial states: l	16.5065	15.0081
	sigma	1.2425	1.1694
	AIC	630.5906	616.0405
	AICc	630.7975	616.2474
	BIC	638.9531	624.4029
Holt linear smoothing	alpha	0.8637	0.7778
	beta	7e-04	1e-04
	phi	0.8413	0.8929
	Initial states: l	15.411	13.9727
	b	1.086	0.9036
	sigma	0.0522	1.1706
	AIC	632.9392	619.1928
	AICc	633.6825	619.9361
	BIC	649.6641	635.9177
Holt-winters' multiplicative method	alpha	0.6485	0.5240
	beta	2e-04	0.1667
	gamma	0.0028	0.0010
	Initial states: l	18.0298	17.2862
	b	0.0668	0.2565
	sigma	0.0530	0.0609
	AIC	646.6704	650.9397
	AICc	652.6704	656.9397
	BIC	694.0577	698.3271
ARIMA		ARIMA (0,1,0)	ARIMA(1,1,0)(1,0,1)
	AR1		-0.2370 (SE=0.0893)
	SAR1		0.8451 (SE=0.01500)
	SMA1		-0.6962 (SE=0.1998)
	sigma^2	1.553	1.286
	log likelihood	-195.03	-183.16
	Ljung-Box test	Q* = 27.455 df = 24 p = 0.2837	Q* = 13.421 df = 21 p = 0.8932
	AIC	392.05	374.32
	AICc	392.09	374.67
	BIC	394.83	385.43

**- Significant at one per cent level

Table 4. Error measures of fitted time series models of feed prices of cattle in Tamil Nadu

Cattle feed Prices	Error measures	Fitted Time series models							
		Mean	Naivem	Driftn	Snaivem	SES (A,N,N)	Holt linear	Holt-winter	ARIMA
Milch cattle feed	ME	5.6458	1.5833	0.9552	2.3333	1.6761	1.7009	0.9574	0.0960
	RMSE	5.7549	1.9364	1.3974	3.3417	2.0131	2.0337	1.8866	1.2408
	MAE	5.6458	1.5833	1.1646	2.6667	1.6761	1.7009	1.5556	0.8376
	MPE	18.9700	5.2181	3.1094	7.7097	5.5323	5.6161	3.0708	0.3103
	MAPE	18.9700	5.2181	3.8572	8.9001	5.5323	5.6161	5.1977	3.4514
	MASE	-	-	-	-	0.6655	0.6754	0.6177	0.3326
	ACF1	0.3850	0.3850	0.3390	0.4256	0.3850	0.3850	0.6368	-0.1403
Dry Cattle feed	Theil's U	4.8213	1.6471	1.1901	2.4925	1.7105	1.7275	1.5230	-
	Accuracy %	81.03	94.78	96.14	91.10	94.47	94.38	94.80	96.55
	ME	4.3625	1.5833	1.0917	2.7500	1.7770	1.8045	-0.0442	0.0481
	RMSE	4.7019	2.3629	1.8771	3.2016	2.4968	2.5163	1.0025	1.1148
	MAE	4.3625	1.9167	1.5385	2.7500	2.0780	2.1009	0.8124	0.8202
	MPE	16.6503	5.7345	3.8671	10.5149	6.4951	6.6032	-0.3123	0.1210
	MAPE	16.6503	7.2496	5.8598	10.5149	7.8635	7.9505	3.2324	3.8147
Dry Cattle feed	MASE	-	-	-	-	0.9370	0.9474	0.3663	0.3698
	ACF1	0.5573	0.5573	0.5141	0.2539	0.5573	0.5573	0.3870	0.0079
	Theil's U	4.0598	1.9333	1.5003	2.7260	2.0641	2.0830	0.8937	-
	Accuracy %	83.35	92.75	94.14	89.49	92.14	92.05	96.77	96.19

Table 5. Comparison of forecasted estimates with actual feed prices of milch cattle and dry cattle feed in Tamil Nadu (in Rs.)

Feed prices	Period	Jan 2022	Feb 2022	Mar 2022	Apr 2022	May 2022	June 2022	Jul 2022	Aug 2022	Sep 2022	Oct 2022	Nov 2022	Dec 2022
Milch cattle feed	Actual	29	31	29	29	29	28	28	29	31	30	31	31
	Mean	23.94	23.94	23.94	23.94	23.94	23.94	23.94	23.94	23.94	23.94	23.94	23.94
	Naivem	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00
	Driftm	28.10	28.19	28.29	28.39	28.48	28.58	28.68	28.77	28.87	28.97	29.06	29.16
	Snaivem	23.00	24.00	28.00	26.00	29.00	29.00	29.00	27.00	29.00	28.00	27.00	28.00
	SES	27.91	27.91	27.91	27.91	27.91	27.91	27.91	27.91	27.91	27.91	27.91	27.91
	Holt linear	27.88	27.88	27.88	27.88	27.88	27.88	27.88	27.88	27.88	27.88	27.88	27.88
	Holt-winter	26.60	27.13	27.85	28.84	29.46	29.20	29.92	28.97	29.70	28.70	28.61	28.51
	ARIMA(0,1,0)	28	28	28	28	28	28	28	28	28	28	28	28
	Actual	22	24	25	25	25	24	25	27	28	27	27	28
Dry Cattle feed	Mean	21.22	21.22	21.22	21.22	21.22	21.22	21.22	21.22	21.22	21.22	21.22	21.22
	Naivem	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00
	Driftm	24.07	24.15	24.22	24.30	24.38	24.45	24.53	24.61	24.68	24.76	24.83	24.91
	Snaivem	20.00	21.00	25.00	21.00	23.00	24.00	24.00	23.00	23.00	23.00	23.00	24.00
	SES	23.81	23.81	23.81	23.81	23.81	23.81	23.81	23.81	23.81	23.81	23.81	23.81
	Holt linear	23.78	23.78	23.78	23.78	23.78	23.78	23.78	23.78	23.78	23.78	23.78	23.78
	Holt-winter	22.75	23.11	24.32	24.71	25.45	25.78	27.14	26.63	27.30	26.85	26.61	26.82
	ARIMA(1,1,0)	23.24	23.58	24.27	23.77	23.90	24.06	24.40	23.93	24.29	24.20	24.02	24.11
	(1,0,1)												

fit SARIMA (1,1,0) (1,0,1) model forecasted the dry cattle feed prices as Rs. 23.24 to Rs. 24.27 for the period of January 2022 to March 2022; Rs. 23.77 to Rs. 24.40 for the period of April 2022 to July 2022 and Rs. 23.93 during August 2022. The forecasted price of dry cattle feed price was around Rs. 24 for the period of September 2022 to December 2022. Alternatively, the forecasted estimates of dry cattle feed price for the period from January 2022 to December 2022 were found to be Rs. 21.22 for the mean model; Rs. 24 for Naive model; Rs. 23.81 for SES model and Rs. 23.78 for Holt linear model. On comparison of forecasted estimates with that of actual values of milch cattle and dry cattle feed prices along with the error estimates of various fitted models, it could be concluded that the best fit models were observed to be the Drift model and ARIMA (0,1,0) models for forecasting of milch cattle feed prices and Holt-winter model and SARIMA (1,1,0) (1,0,1) for forecasting of dry cattle feed prices.

The estimated parameter of the time series models for cattle feed prices is shown in Table 3. The magnitude of change (drift) in the time series data of prices of milch cattle feed was based on the average change noticed in the training set data. For the best fit model for forecasting of milch cattle feed price was observed to be ARIMA (0,1,0), which indicated that there were no coefficients for Auto regression and Moving Average coefficients. The Log likelihood was noticed to be -195.03. The AIC, AICc and BIC values of the ARIMA (0,1,0) was estimated to be 392.05, 392.09 and 394.83. The ARIMA residuals are assumed to be independent, which could be

confirmed by the Ljung-Box test Q statistic (27.455) and p-value (0.2837).

In case the dry cattle feed prices, the best fit model was observed to be Holt-winter multiplicative model and the estimated parameters as shown in Table 3 were 0.5240 (alpha), 0.1667 (beta), 0.0010 (gamma) and 0.2565 (b). The AIC, AICc and BIC values the mentioned model was 650.94, 656.94 and 698.33, respectively. On the other hand, the best fit model for dry cattle feed price forecasting was estimated as SARIMA (1,1,0)(1,0,1) and coefficients were calculated as -0.2370 (First order Auto Regression), 0.8451 (First order Seasonal Auto Regression) and -0.6962 (First order Seasonal Moving Average. The variance and log likelihood of the mentioned model was estimated as 1.286 and -183.16, respectively. On comparison with the Holt-winter model, SARIMA (1,1,0)(1,0,1) model had the lowest values of AIC (374.32), AICc (374.67) and BIC (385.43) values, which indicated the best fit nature of the model. Further, Q (13.421) and p (0.8932) values of Ljung-Box test implied that the ARIMA residuals are independent, which concurs with primary assumption of ARIMA model.

The actual price data (training set) for the milch cattle feed prices for the period from January 2012 to December 2021, predicted price forecasts (test data for the period January 2022 to December 2022) and also the forecast values beyond dataset (January 2023 to December 2023) is depicted in Figure 1 for Random drift model and Figure 2 for ARIMA (0,1,0) model. The plots comprised of point estimate along with 80 per cent and 95 per cent

Table 6. Forecasted point estimates of feed prices of cattle in Tamil Nadu using best fit time series models for the year 2023

Month	Forecasted Milch cattle feed price		Forecasted Dry cattle feed price	
	Drifttm model	ARIMA (0,1,0)	Holt-winter	ARIMA(1,1,0) (1,0,1)
January 2023	29.25	28.00	26.08	23.65
February 2023	29.35	28.00	26.45	23.90
March 2023	29.45	28.00	27.80	24.49
April 2023	29.55	28.00	28.19	24.07
May 2023	29.64	28.00	29.00	24.17
June 2023	29.74	28.00	29.34	24.31
July 2023	29.84	28.00	30.84	24.59
August 2023	29.93	28.00	30.22	24.20
September 2023	30.03	28.00	30.93	24.51
October 2023	30.13	28.00	30.39	24.43
November 2023	30.22	28.00	30.08	24.28
December 2023	30.32	28.00	30.28	24.35

confidence intervals. Further, non-violation of basic assumptions of ARIMA was ensured based on the plots of ARIMA residuals. Similarly, the forecast plots of dry cattle feed prices in Tamil Nadu for the training data (January 2012 to December 2021), Test data (January 2022 to December 2022) and Short term forecasts beyond data set (January 2023 to December 2023) is displayed in Figure 3 for Holt linear winter model and Figure 4 for

SARIMA (1,1,0) (1,0,1) model. The ARIMA residuals plot was also fitted to ensure the normality assumption.

The forecasted point estimate of the feed prices of milch cattle and dry cattle is shown in Table 6. The price of milch cattle feed estimated through ARIMA (0,1,0) model for the period January 2023 to December 2023 was Rs.28, whereas it was 29.25 to 30.32 for the random drift model for the mentioned

period. Hence, comparatively random drift model might be good for prediction of feed prices of dairy cattle. In case of dry cattle feed price, the point estimate of Holt-winter model was found to be Rs. 26.08 for the month of January 2023, which gradually increased to Rs. 30.28 for the month of December 2023. However, it was estimated to be Rs.23.65 to Rs. 24.35 for the mentioned period for ARIMA (1,1,0) (1,0,1) model.

CONCLUSION

The time series data on feed prices of the milch cattle and dry cattle comprised of the trend, seasonal, cyclical and irregular components. The best fit time series model for the milch cattle feed prices was estimated to be Random drift model and ARIMA (0,1,0). Further, Holt-winter multiplicative model and SARIMA (1,1,0) (1,0,1) were identified as the best fit models for the dry cattle feed price forecasting. Hence, these models could be utilized by the feed manufacturers, market functionaries and dairy entrepreneurs to predict the short term price forecasts of cattle feed for efficient planning and making right decisions.

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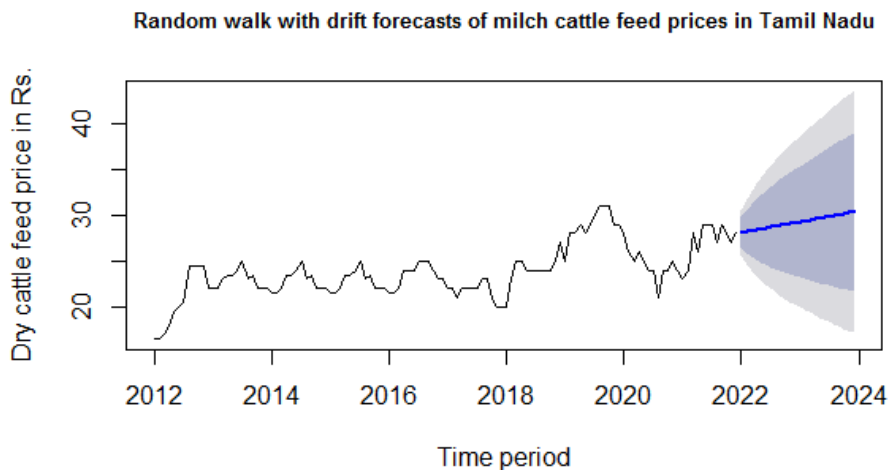


Fig.1. Best fit Random drift forecasts of milch cattle feed prices in Tamil Nadu

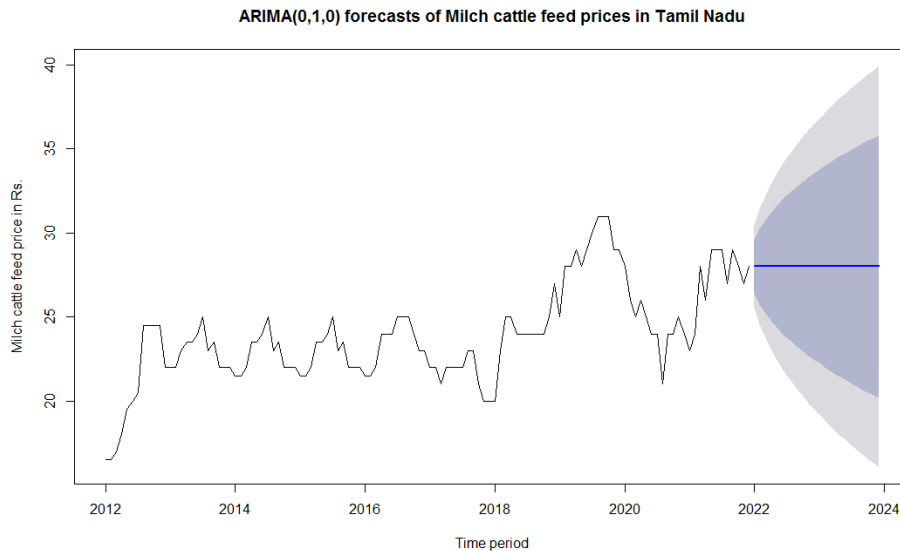


Fig. 2. Best fit ARIMA (0,1,0) forecasts of milch cattle feed prices in Tamil Nadu

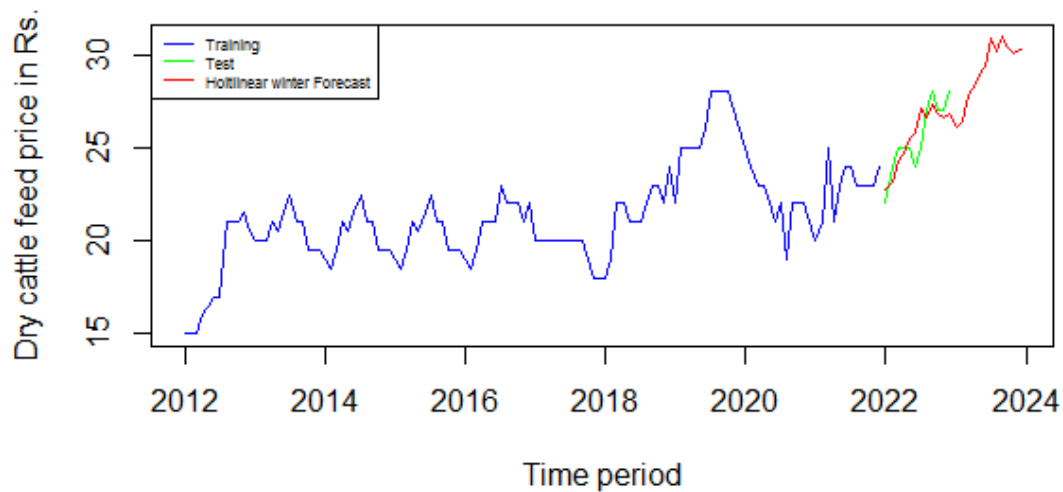


Fig.3. Forecast plots of dry cattle feed prices in Tamil Nadu –Holt linear winter model

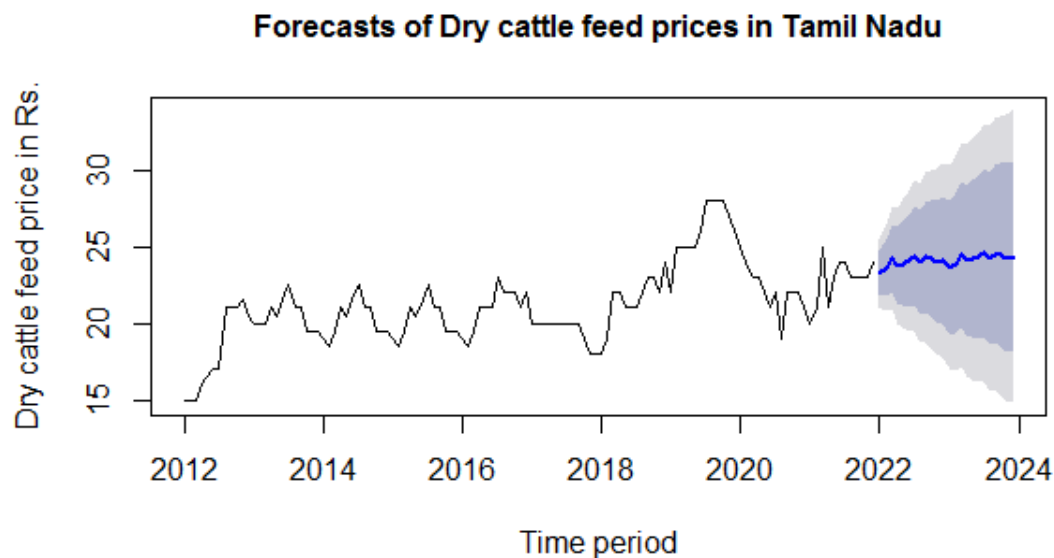


Fig.4. Best fit ARIMA (1,1,0) (1,0,0) forecasts of dry cattle feed prices in Tamil Nadu