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Trend in collection of Tendu leaves in Kondagaon Chhattisgarh

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Abstract

Tendu leaves (*Diospyros melanoxylon*) are an important non-timber forest product in Chhattisgarh, providing seasonal employment and income to a large tribal population. The present study examines the trend in Tendu leaves collection in Kondagaon district of Chhattisgarh using time series data. Straight-line, polynomial regression models up to the fourth order, and exponential regression models were fitted using the least squares method. The adequacy of the models was evaluated through ANOVA, F-tests, p-values, and the coefficient of determination (R^2). The results indicated that none of the fitted models were statistically significant at the 5% or 1% levels. However, the fourth order polynomial regression model showed the highest explanatory power with an R^2 value of 0.437, explaining 43.7% of the variation in Tendu leaves collection. The fitted curve showed a moderate agreement between observed and estimated values. The study suggests that factors other than time influence Tendu leaves collection, and inclusion of additional variables may improve future forecasting and analysis.

Keywords: Tendu, Kondagaon Chhattisgarh, *Diospyros melanoxylon*, estimation, determination

Introduction

The leaves of Tendu tree (*Diospyros melanoxylon*) are an important non-timber forest product for Indian state of Chhattisgarh. Popularly known as “green gold of forest” which provides the seasonal employment and income of 13 lakhs families in Chhattisgarh. Chhattisgarh is the 9th-largest state in India with an area of 135,192 km² (52,198 sq m). Chhattisgarh is a forested state in central India. In Chhattisgarh, forest covers 5.6 million hectares area which occupies 41.33% of the total area (as per the latest report by the Indian Forest Service) and the rich forest resources include wood, Tendu leaves, honey and Lac. Approximately 3% is under very dense forest, 25.97% is moderately dense, 12.28% is open forest and 0.09% is scrub. Tendu (*Diospyros melanoxylon*) leave collection, one of the non-timber forest produce (NTFPs) largely distributed in central peninsular India such as Madhya Pradesh, Orissa, Chhattisgarh, Jharkhand, part of Maharashtra and Andhra Pradesh.

The Tendu leaves are used as Bidi (Rural form of cigarette) wrappers. About 550 billion pieces of Bidi (rolled by 10 million people) are sold every year in India, according to the All-India Bidi Industry Federation. Moreover, gathering Tendu is labour-intensive and employs millions of tribals during the lean month of May, when they have very little else to earn from. As we know that Chhattisgarh is a tribal-dominated state, where most of the people are dependent on forest products. According to Census 2011, tribal's population covers 32.5% of total population who live in dense forest area of the state (C.G.) Like Surguja, Bastar, Deatowada, Sukma, Kanker, Bijapur, Bilaspur, Narayanpur. Gaurella-Pendra-Marwahi districts. In the 1960s, the governments realised the commercial value of Tendu.

Most of the land from which Tendu was plucked belonged to the state governments. Tendu leaves were sold unplucked to contractors, who under-reported the collections. This resulted in revenue loss. The tribal people who collected these leaves also got precious little. Several states decided to change this and passed laws to 'Nationalise' the Tendu trade in the 1960-1970. The purpose: to ensure maximum revenue for the governments and better returns to the tribal collectors.

The most crucial in this was Madhya Pradesh (MP), the largest state in India at that time. Before Chhattisgarh (CG) was created out of it in 2000, MP 1 produced about 45 per cent of the country's total harvest of Tendu. Now, it is about 25 per cent. The collection of leaves and rolling of Bidi constitutes a sector worth an estimated Rs 2,000 crore in MP and CG.

Chhattisgarh is a pioneer state of India, producing the best quality Tendu (*Diospyros melanoxylon*) leaves. The production of Tendu leaves is approximately 16.44 Lacs standard bags annually, which is nearly 20% of the total Tendu leave production of the country. One standard bag of Tendu leaves in Chhattisgarh comprises of 1000 bundles of 50 leaves each. In Chhattisgarh the collection season is from third week of April to second week of June. The collection season starts earlier in the Southern part of the state in comparison to Northern part of the state. The State is divided into 31 district Unions and 916 Primary Forest Produce Co-operative Societies. Tendu leave is a nationalized non-wood forest produce (NTFP). Tendu leave is most important non-timber forest product that serves as a big revenue earner for the state government but is an important economic resource to the indigenous tribes and local population during the summer month when they have no other form of employment. The total income generated from nationalized NTFPs is very significant for the total forest revenue in Chhattisgarh. The collection rate for Tendu leave is Rs. 4000/-per standard Bag for the year 2022. Looking to the collection of Tendu leaves the following objectives are framed.

Materials and Methods

Location of study

The study will be conducted in Kondagaon district of the Chhattisgarh Baster Plateau Agro-climatic Zone. The area under study which situated at 19.5954° N latitude and 81.6646° E longitude.

Estimate of the trend in collections of Tendu leaves in Kondagaon

Analytical method

The time series data on the yearly collections and sales of Tendu leaves will be analyzed by using Least Square Analysis, the various models will be as follows:

Model-1 straight line trend

$$Y_t = a + bt + e$$

Where,

Y_t = estimated Tendu leaves collections per sales

a = constant

b = regression coefficients

t = time variable

e = error term

Model-II exponential function

$$Y_t = ab^t + e \text{ or } \log y = \log a + t \log b \text{ or } Y = A + B_t + e$$

Where,

Y = estimated Tendu leaves collections/sales for different years

A = $\log a$ B = $\log b$

T = time variable

E = Error term

Model-III 2nd order polynomial regression model

$$Y_t = b_0 + b_1t^1 + b_2t^2 + e$$

Where,

Y = Estimated Tendu leaves collections/sales for different years

b_0, b_1, b_2 = Estimated regression coefficient

T = Time Variable

E = Error Term

Model-IV 3rd order polynomial regression model

$$Y_t = b_0 + b_1t^1 + b_2t^2 + b_3t^3 + e$$

Where,

Y = Estimated Tendu leaves collections/sales for different years

b_0, b_1, b_2, b_3 = Estimated regression coefficient

T = Time Variable

E = Error Term

Model-V 4th order polynomial regression model

$$Y_t = b_0 + b_1t^1 + b_2t^2 + b_3t^3 + b_4t^4 + e$$

Where,

Y = Estimated Tendu leaves collection/sales for different years

b_0, b_1, b_2, b_3, b_4 = Estimated regression coefficient

T = Time Variable

E = Error Term

The following formula will be used to perform a "t" test to determine the significance of the regression coefficient:

$$t = b_i / \text{S.E.}(b_i) \text{ with } n-2 \text{ degree of freedom}$$

Where,

b_i = Estimated value of b_i

S.E.(b_i) = Standard Error of b_i

N = Number of observations

i = 0, 1, 2, 3, 4

To find out the contribution of Kondagaon, we will be showing it graphically and in percentages as well.

Results

Curve fitting of Tendu leaves collection in Kondagaon Chhattisgarh

Polynomial regression up to fourth order and exponential regression are presented in table 1 to 6 respectively. The table 1 revealed that the fitted regression line is not a good fit since F calculated was not found significant. Second order, third order and exponential regression models were not well fitted since F calculated values were not found significant as shown in Table no. 3, 4 and 5 Table 6 represent the ANOVA for fourth order regression equation. It was observed from the table that the fitted model is highly significant.

Thus, the equation and R^2 value of the best fitted model for Tendu leaves collection are given in Table 2 the observed and fitted curve for the model was shown in Fig. 2. The critical observation of Table 3 indicated that fourth-order regression model was the best fitted model in explaining the Tendu leaves collection. The regression coefficient was found highly significant.

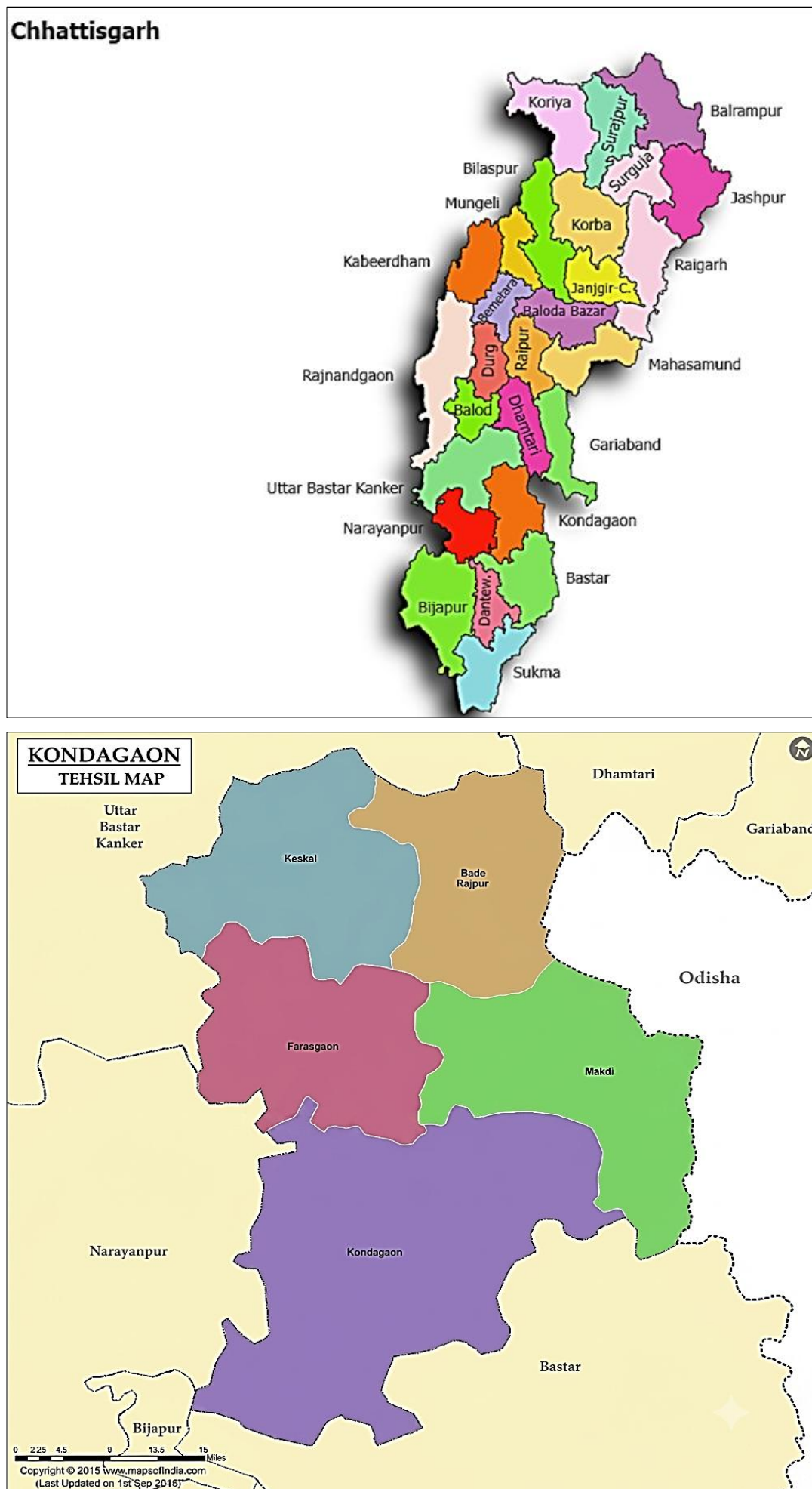


Fig 1: Map of the location of study

Table 1: ANOVA for straight line

	DF	SS	MS	F	Significance F			
Regression	1	32.202	32.202	5.121795	0.05346			
Residual	8	50.298	6.28725					
Total	9	82.5						
	Coefficients	Standard Error	T-Stat	P-Value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	2024.106	3.45291	586.2029	8.03E-20	2016.143	2032.068	2016.143	2032.068
X Variable 1	-0.00039	0.000174	-2.26314	0.05346	-0.00079	7.45E-06	-0.00079	7.45E-06

**Significant 1% level

*Significant at 5% level

The ANOVA for straight-line regression gives an F-value of 5.1218 with a p-value of 0.05346. Since the p-value is greater than 0.05 and 0.01, the regression is not significant at both 5%

and 1% levels. Hence, there is no significant linear relationship between the variables.

Table 2: ANOVA for Second order polynomial regression model

	DF	SS	MS	F	Significance F			
Regression	2	33.86113234	16.9306	2.436610244	0.157345119			
Residual	7	48.63886766	6.94841					
Total	9	82.5						
	Coefficients	Standard Error	T-Stat	P-Value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	2031.437156	15.43661062	131.599	3.85895E-13	1994.935372	2067.93894	1994.935372	2067.93894
X Variable 1	-0.001260324	0.001783301	-0.70674	0.502570266	-0.005477162	0.002956513	-0.005477162	0.002956513
X Variable 2	2.38922E-08	4.88944E-08	0.48865	0.640025934	-9.17247E-08	1.39509E-07	-9.17247E-08	1.39509E-07

**Significant 1% level

*Significant at 5% level

The ANOVA for the second order polynomial regression model shows an F-value of 2.4366 with a p-value (Significance F) of 0.1573. Since this p-value is greater than 0.05 and 0.01, the regression model is not significant at both 5% and 1% levels. The p-values of both regression

coefficients (Linear and quadratic terms) are also greater than 0.05. Hence, the second order polynomial model does not provide a significant fit, and there is no significant relationship between the variables.

Table 3: ANOVA for third order polynomial regression model

	DF	SS	MS	F	Significance F			
Regression	3	41.96476	13.98825	2.070532	0.205633			
Residual	6	40.53524	6.755873					
Total	9	82.5						
	Coefficients	Standard Error	T-Stat	P-Value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	2101.033	65.34321	32.15381	6.02E-08	1941.144	2260.922	1941.144	2260.922
X Variable 1	-0.01341	0.011233	-1.19391	0.27757	-0.0409	0.014075	-0.0409	0.014075
X Variable 2	6.99E-07	6.19E-07	1.130502	0.30142	-8.1E-07	2.21E-06	-8.1E-07	2.21E-06
X Variable 3	-1.2E-11	1.1E-11	-1.09521	0.315427	-3.9E-11	1.49E-11	-3.9E-11	1.49E-11

**Significant 1% level, *Significant at 5% level

The third order polynomial regression model has an F-value of 2.0705 with a p-value of 0.2056. Since the p-value is greater than 0.05, the model is not statistically significant.

Hence, the third order polynomial regression does not provide a significant fit to the data.

Table 4: ANOVA for fourth order polynomial regression model

	DF	SS	MS	F	Significance F			
Regression	4	48.40599367	12.1015	1.774725	0.270833676			
Residual	5	34.09400633	6.818801					
Total	9	82.5						
	Coefficients	Standard Error	T-Stat	P-Value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	1566.54659	553.8331218	2.828553	0.036737	142.8732275	2990.219953	142.8732275	2990.219953
X Variable 1	0.110503875	0.127993373	0.863356	0.427405	-0.218513566	0.439521315	-0.218513566	0.439521315
X Variable 2	-9.73089E-06	1.07496E-05	-0.90523	0.406846	-3.73637E-05	1.79019E-05	-3.73637E-05	1.79019E-05
X Variable 3	3.66664E-10	3.89839E-10	0.940553	0.390117	-6.35449E-10	1.36878E-09	-6.35449E-10	1.36878E-09
X Variable 4	-5.02104E-15	5.1661E-15	-0.97192	0.375728	-1.83009E-14	8.25885E-15	-1.83009E-14	8.25885E-15

**Significant 1% level, *Significant at 5% level

The fourth order polynomial regression model has an F-value of 1.7747 with a p-value of 0.2708. As the p-value is greater

than 0.05, the model is not significant, indicating that the fourth order polynomial does not fit the data significantly.

Table 5: ANOVA for exponential function

	DF	SS	MS	F	Significance F			
Regression	1	0.050366077	0.050366	4.760055	0.065471			
Residual	7	0.074066906	0.010581					
Total	8	0.124432983						
	Coefficients	Standard Error	T-Stat	P-Value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	62.70278	26.785127	2.340955	0.051772	-0.63398	126.0395	-0.63398	126.0395
X Variable 1	-0.02897	0.013279675	-2.18176	0.065471	-0.06037	0.002428	-0.06037	0.002428

**Significant 1% level, *Significant at 5% level

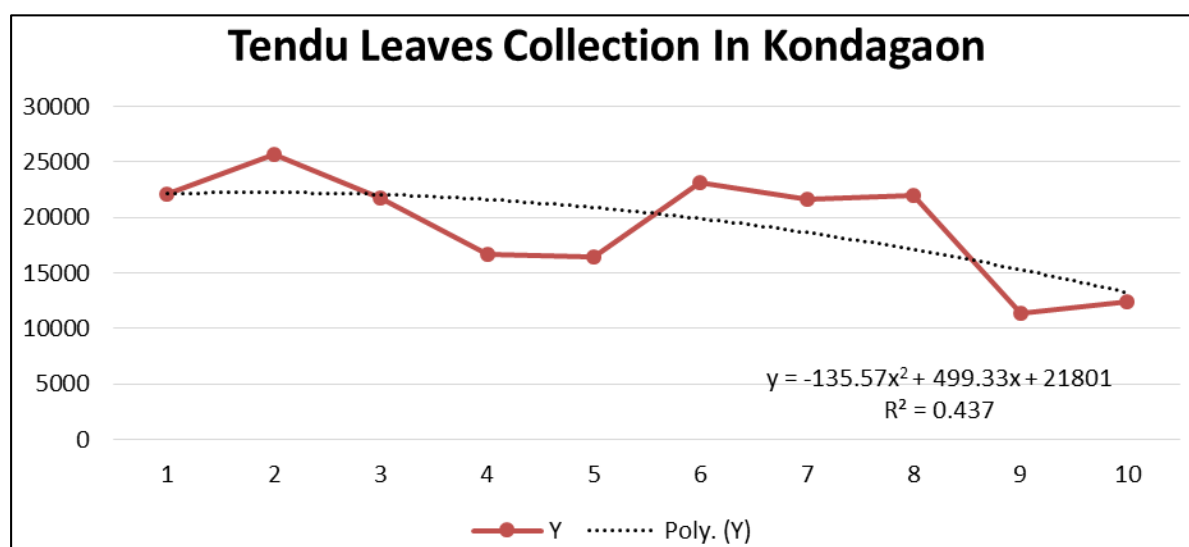
The exponential regression model has an F-value of 4.7601 with a p-value of 0.0655. As the p-value exceeds 0.05, the

model is not significant, indicating that the exponential function does not fit the data significantly.

Table 6: Fitted curve and R^2 value of Tendu leaves collection in Kondagaon

Model	Equation	R^2
Fourth order polynomial regression	$Y = -135.57x^2 + 499.33x + 21801$	0.437

**Significant 1% level, *Significant at 5% level

**Fig 2:** Fitted curve and R^2 value of Tendu leaves collection in Kondagaon

The fitted curve for Tendu leaves collection in Kondagaon follows a fourth order polynomial trend given by

$$(Y = -135.5x^2 + 499.3x + 21801).$$

The coefficient of determination ($R^2 = 0.437$) indicates that the model explains about 43.7% of the variation in Tendu leaves collection, showing a moderate fit between the observed data and the fitted curve.

Discussion

Curve fitting techniques were applied to analyze the trend in Tendu leaves collection in Kondagaon district of Chhattisgarh using straight line, polynomial regression models up to fourth order, and exponential regression. The adequacy of each model was assessed using ANOVA, F-test, p-values, and the coefficient of determination (R^2).

The straight-line regression model was found to be statistically non-significant, as the calculated F-value (5.1218) did not attain significance at either the 5% or 1% level. This indicates the absence of a significant linear relationship between time and Tendu leaves collection.

Similarly, the second order polynomial regression model showed a non-significant F-value (2.4366) with a high p-value (0.1573), indicating that inclusion of the quadratic term did not significantly improve the model fit. The regression coefficients were also not statistically significant.

The third order polynomial regression model further failed to provide a significant fit, as reflected by the non-significant F-value (2.0705). None of the regression coefficients corresponding to linear, quadratic, or cubic terms were statistically significant, suggesting that higher-order polynomial terms did not adequately explain the variation in Tendu leaves collection.

The fourth order polynomial regression model also resulted in a non-significant F-value (1.7747) at the 5% level. Although the regression coefficients were statistically non-significant, this model yielded the highest coefficient of determination ($R^2=0.437$) among all models considered, indicating a comparatively better explanatory power.

The exponential regression model was also found to be statistically non-significant, with an F-value of 4.7601 and a p-value of 0.0655, implying that the exponential trend does not adequately describe the pattern of Tendu leaves collection. Despite the lack of statistical significance in all tested models, the fourth order polynomial regression explained a relatively higher proportion of variability in the data, as indicated by its R^2 value.

Conclusion

For Kondagaon district, the best-fitted model was fourth-order regression model for estimation of Tendu leaves collection and third-order regression model for estimation of Tendu leaves sale with R^2 value (0.437) in Chhattisgarh state for

next two years was estimated and the highest Tendu leaves collection was estimated as 12.903 (Per standard bags).

The Kondagaon contributes 1% in total to the collection of Tendu leaves in Chhattisgarh. In Kondagaon District, for Tendu leaves collection marked a significantly increasing trend, the best fitted model was $Y = -135.57x^2 + 499.33x + 21801$, which showed the highest R^2 value. Tendu leaves collected were 299.66 lakh standard bags in Chhattisgarh state and 1.932 lakh standard bags in Kondagaon district.

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