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Forecasting land utilization of India and Maharashtra using ARIMA model

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Abstract

India is an agricultural country with Maharashtra state as its major contributor to the agriculture sector. In agriculture, land is the most important component. Hence, the land utilization pattern of India and Maharashtra state has been studied during this analysis over the past 11 years (2011-2022). The ACF (Auto Correlation Function) and PACF (Partial Auto Correlation Function) were calculated for the data. The future aspect of land by forecasting land utilization for the next 10 years has been done by using the Appropriate Box-Jenkins ARIMA (Auto Regressive Integrated Moving Average) model. The forecasted results show an increase in some categories of land and a decrease in other categories, while for some land there were no changes occurred. This land forecasting will play a major role in the development and planning of agriculture and other allied sectors of India as well as Maharashtra state.

Keywords: ARIMA model, land utilization, forecasting, Box-Jenkins methodology/ procedure, ACF, PACF, Forest area, Non-available for Cultivation, Fallow land, Land excluding fallow land, Net sown area, Area sown more than once, Total cropped area, Cultivable area, Cultivated area

1. Introduction

Land utilization is nothing but the use of all available and vacant land of a region in a given period. (Ubale G S, 2023) [14] Due to urbanization, increasing population and deforestation there is a shift in land use patterns which adversely influence the total cropped area available. Agricultural expansion is often a response to wide land reforms causing economic changes. The use of land is essential to social dynamics, economic expansion, environmental management and sustainable development. Understanding and predicting land use patterns is crucial for efficient planning and resource management in India, especially in Maharashtra. A promising method for precise forecasting is the Autoregressive Integrated Moving Average (ARIMA) model, which takes into account temporal information such as trends, seasonality and cyclic behaviours (Lai & Dzombak, 2020) [8]. This study uses the ARIMA model to forecast land use in India and Maharashtra state. It provides a thorough analysis of land use trends and projects future patterns. To improve understanding of land use dynamics and support efficient management strategies in the face of socioeconomic and environmental changes, the study makes use of historical land utilization data and statistical techniques. It is anticipated that the results will have a major impact on land management and serve as a basis for further investigation.

2. Data source and Methodology

ARIMA models were utilized to predict future values based on annual data on land utilization from 2011 to 2022. The Box-Jenkins methodology is another name for the ARIMA methodology. Fitting a mixed Auto-Regressive Integrated Moving Average (ARIMA) model to a given data set is the focus of the Box-Jenkins procedure. Accurately predicting future values and determining the stochastic process of time series are the key objectives of fitting this ARIMA model. (Granger and Newbold, 1970) [7].

On the other hand, the stochastic model for a time series determines the best estimate of its future values. Either stationary or non-stationary processes are stochastic. First of all, keep in mind that the ARIMA model only applies to stationary time series; most time series are non-stationary. The first step of the Box-Jenkins model involves taking first-order differences to convert the non-stationary series to a stationary series because the ARIMA models only apply to stationary time series.

Establishing a Box-Jenkins forecasting model involves the following steps:

1. Identification
2. Estimating the parameters
3. Diagnostic checking and
4. Forecasting

Step 1: Identification: Firstly, the proper values for p, d, and q are determined. The Autocorrelation Function (ACF), Partial Autocorrelation Function (PACF) and the resulting correlograms and partial correlograms are the tools used for identification.

Step 2: Estimation: After the values of p and q have been determined, simple least squares are used to estimate the parameters of the autoregressive and moving average terms.

Step 3: Diagnostic checking: The fitness of a given ARIMA model is confirmed after selecting it and estimating its parameters.

Step 4: Forecasting: The effectiveness of ARIMA modeling in forecasting is one of the factors contributing to its widespread use. The relationship between a time series variable and its past value can be expressed using an Autoregressive Integrated Moving Average Process model. Mainly an ARIMA model is used to produce the best weighted average forecasts for a single time series (Rahulamin and Razzaque 2000) [13].

Data

The annual data on Land Utilization for the period from 1951 to 2022 for India and 2007 to 2022 for Maharashtra were used for forecasting future values using ARIMA models.

3. Results and Discussion

ARIMA Forecasting of India

1) Forest Area Forecast of India

ARIMA Model

ARIMA (2,2,2): 569.4145
ARIMA (0,2,0): 583.9896
ARIMA (1,2,0): 578.966
ARIMA (0,2,1): 565.892
ARIMA (1,2,1): 567.6664
ARIMA (0,2,2): 567.4664
ARIMA (1,2,2): 568.623
Best model: ARIMA (0,2,1)
AIC= 565.89 BIC= 570.39

The above output provides selected tentative ARIMA (Auto Regressive Integrated Moving Average) models for forecasting variables of interest in the context of land utilization in India and Maharashtra state. Each model is represented by its parameters (p, d, q), corresponding Akaike Information Criterion (AIC) values and Bayesian Information Criterion (BIC) values.

For the forecast of forest land utilization, the ARIMA model with parameters (0,2,1) exhibits the lowest AIC value, indicating it as the best-fitting model among the selected options. This suggests that a simple differencing of the series may be sufficient to achieve stationary and no further autoregressive or moving average terms are necessary.

Table 1: Forecasted Values for the Next 10 Years

Year	Forecasted Values
2023	720.6099
2024	721.2198
2025	721.8298
2026	722.4397
2027	723.0496
2028	723.6595
2029	724.2694
2030	724.8794
2031	725.4893
2032	726.0992

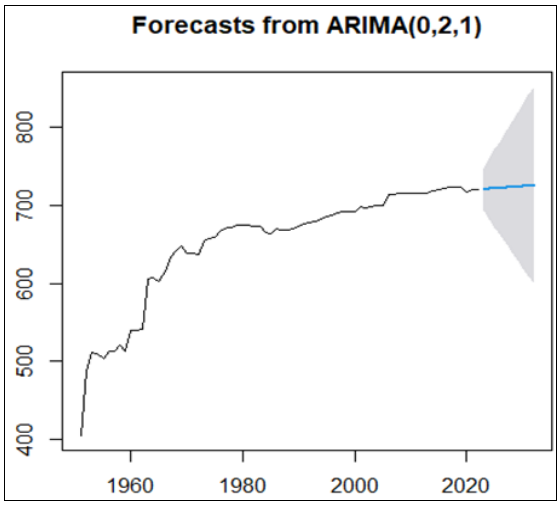

Fig 1: Forecast graph of forest area

It can be seen from Table 1 that there will be a modest increase in the forest area from 720.6099 ha in 2023 to 726.0992 ha in 2032 about 0.84 per cent. This suggests a slight improvement in forest cover.

Fig. 1 provides the plot for an 11-year projection of the forecasting of forest land utilization in India obtained by fitting the ARIMA (0,2,1) best fit model to our time series data.

2) Not Available for Cultivation Area Forecast of India

ARIMA Model

ARIMA (0,1,0): 487.6667
ARIMA (2,1,2): 482.1226
ARIMA (2,1,1): 488.7717
ARIMA (3,1,2): 484.0942
ARIMA (1,1,1): 488.0939
ARIMA (1,1,3): 485.6439
ARIMA (3,1,1): 490.6497
ARIMA (3,1,3): 486.0435
Best model: ARIMA (2,1,2)
AIC=482.12 BIC=493.44

The above output provides selected tentative ARIMA models which are represented by its parameters (p, d, q), AIC values and BIC values.

For the forecast of not available for cultivation land utilization in India, the ARIMA model with parameters (2,1,2) exhibits the lowest AIC value, indicating it as the best-fitting model among the selected options. This suggests the series may be sufficient to achieve stationary and no further moving average terms.

Table 2: Forecasted Values for the Next 10 Years

Year	Forecasted Values
2023	441.9140
2024	441.5921
2025	440.7107
2026	439.9982
2027	439.7725
2028	439.9452
2029	440.2477
2030	440.4572
2031	440.4990
2032	440.4234

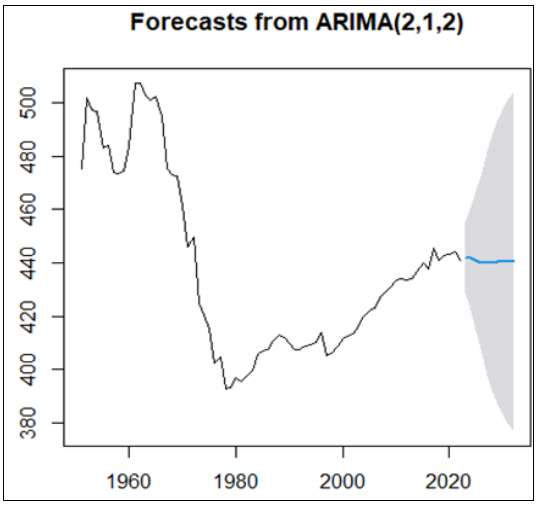

Fig 2: Forecast graph of Not Available for Cultivation Area

Table 2 gives that the area non-available for cultivation is expected to decrease by 0.11 per cent from 441.9140 ha in 2023 to 440.4234 ha in 2032, indicating a slight reduction in land that cannot be used for agricultural purposes. This might be the sign of risk for food security as the agricultural land is seen to be decreased.

Fig. 2 shows the plot for an 11-year projection of the forecasting of Not Available for Cultivation land utilization in India obtained by fitting the ARIMA (2,1,2) best fit model to our time series data.

3) Fallow lands Forecast of India

ARIMA Model

ARIMA (2,1,2) with drift: Inf
ARIMA (0,1,0): 656.1411
ARIMA (0,1,1): 635.3836
ARIMA (1,1,1): 637.3758
ARIMA (0,1,2): 637.3769
ARIMA (1,1,0): 641.4353
ARIMA (1,1,2): 638.1142
Best model: ARIMA (0,1,1)
AIC=635.38 BIC=639.91

The output above presents a selection of approximate ARIMA models, denoted by their parameters (p, d, q), as well as their AIC and BIC values.

The ARIMA model with parameters (0,1,1) has the lowest AIC value for the forecast of fallow land utilization in India, making it the best-fitting model out of the ones that were chosen. This shows that the series might be enough to produce stationary values without the need for additional moving average terms.

Table 3: Forecasted Values for the Next 10 Years

Year	Forecasted Values
2023	247.9861
2024	247.9862
2025	247.9863
2026	247.9864
2027	247.9865
2028	247.9866
2029	247.9867
2030	247.9868
2031	247.9869
2032	247.9870

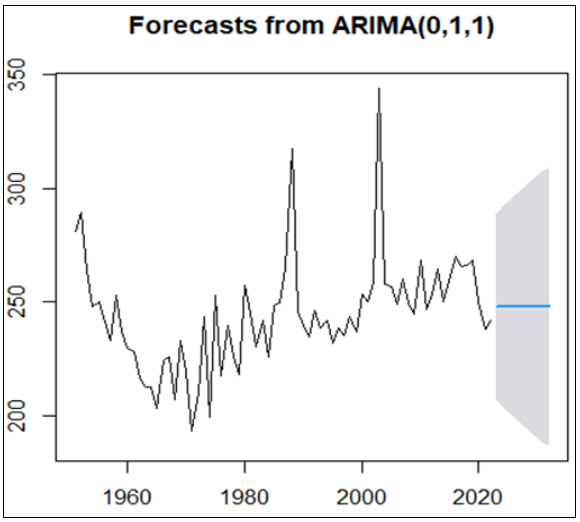

Fig 3: Forecast graph of Fallow land

In Table 3, fallow land or the land left uncultivated for a period will be increased by 2.59 per cent. Going from 247.9861 ha to 247.9870 ha from 2023 to 2032. This could imply either an increase in the land being left idle or a shift in how land is categorized.

Fig. 3 gives the plot for an 11-year projection of the forecasting of Fallow land utilization in India obtained by fitting the ARIMA (0,1,1) best fit model to our time series data.

4) Area excluding Fallow lands Forecast of India

ARIMA Model

ARIMA (2,1,2) with drift: Inf
ARIMA (0,1,0) with drift: 547.8937
ARIMA (1,1,0) with drift: 549.8425
ARIMA (0,1,1) with drift: 549.8583
ARIMA (0,1,0) : 552.2543
ARIMA (1,1,1) with drift: 551.8109
Best model: ARIMA (0,1,0) with drift
AIC=547.89 BIC=552.42

The above output provides parameters (p, d, q), AIC values and BIC values which represents selected tentative ARIMA models.

The ARIMA model with parameters (0,1,0) with drift has the lowest AIC value among the chosen options, making it the best-fitting model for the forecast of area in India that excludes fallow land utilization. This shows that there might not be a need for additional moving average terms if the series is adequate to produce stationary.

Table 4: Forecasted Values for the Next 10 Years

Year	Forecasted Values
2023	248.7270
2024	245.3141
2025	241.9011
2026	238.4882
2027	235.0752
2028	231.6623
2029	228.2493
2030	224.8363
2031	221.4234
2032	218.0104

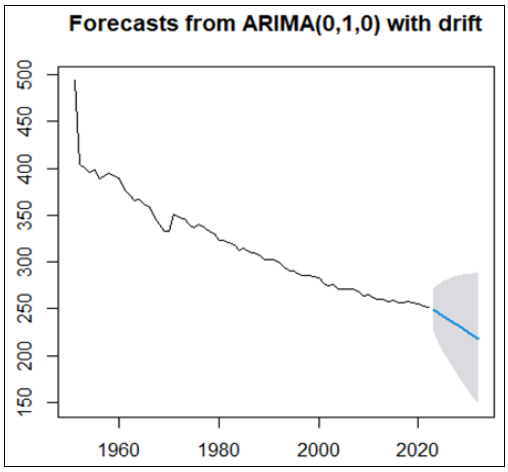

Fig 4: Forecast of Area excluding Fallow lands

There will be a significant decrease from 248.7270 ha to 218.0104 ha (13.54%) during the period of 2023 to 2032 in land excluding fallow land which can be observed in Table 4. This suggests a substantial reduction in the amount of land available for continuous cultivation.

Fig. 4 depicts the plot for an 11-year projection of the forecasting of Area excluding Fallow land utilization in India obtained by fitting the ARIMA (0,1,0) with drift best fit model to our time series data.

5) Net Sown Area Forecast of India

ARIMA Model

ARIMA (2,1,2) with drift: 657.1409
ARIMA (0,1,0) with drift: 667.5601
ARIMA (1,1,0) with drift: 655.4025
ARIMA (0,1,1) with drift: 654.8468
ARIMA (0,1,0) : 666.5935
ARIMA (1,1,1) with drift: 656.0321
ARIMA (0,1,2) with drift: 655.7078
ARIMA (1,1,2) with drift: 655.1417
ARIMA (0,1,1) : 656.0987
Best model: ARIMA (0,1,1) with drift
AIC=654.85 BIC=661.63

Using its parameters (p, d, q), AIC values, and BIC values, the output above presents a selection of tentative ARIMA models.

The ARIMA model, which has parameters of (0,1,1) with drift has the lowest AIC value among the models chosen to forecast net sown land utilization in India. That makes it the best-fitting model. This shows that the series might be enough to produce stationary values without the need for additional moving average terms.

Table 5: Forecasted Values for the Next 10 Years

Year	Forecasted Values
2023	1413.563
2024	1416.543
2025	1419.523
2026	1422.503
2027	1425.484
2028	1428.464
2029	1431.444
2030	1434.424
2031	1437.404
2032	1440.384

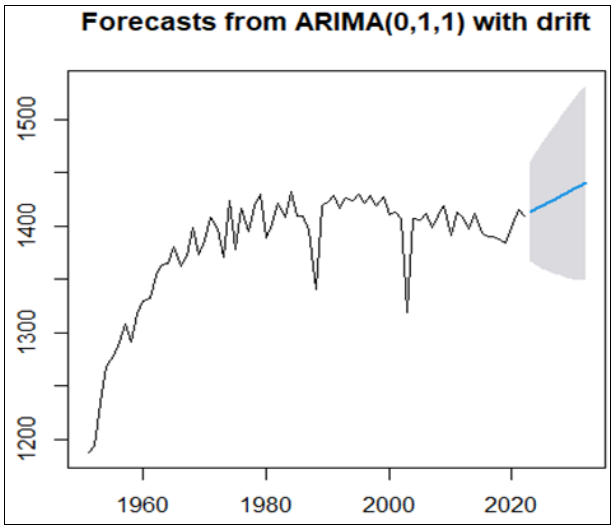

Fig 5: Forecast of Net sown area

Table 5 shows that the area actually sown with crops is expected to increase by 2.15 per cent over the next 10 years from 1413.563 ha to 1440.384 ha, indicating a rise in the area actively used for cultivation.

Fig. 5 gives the plot for an 11-year projection of the forecasting of Net sown land utilization in India obtained by fitting the ARIMA (0,1,1) with drift best fit model to our time series data.

6) Area Sown More than Once Forecast of India

ARIMA Model

ARIMA (2,1,2) with drift: 645.708
ARIMA (1,1,0) with drift: 647.3335
ARIMA (0,1,0): 664.4151
ARIMA (1,1,2) with drift: 648.0067
ARIMA (2,1,1) with drift: 649.5539
RIMA (3,1,3) with drift: 649.5934
ARIMA (2,1,2): 656.0818
Best model: ARIMA (2,1,2) with drift
AIC=645.71 BIC=659.28

The output above offers a selection of similar ARIMA models, denoted by their parameters (p, d, q), as well as their AIC and BIC values.

The ARIMA model with parameters (2,1,2) with drift has the lowest AIC value, resulting in the best-fitting model for the forecast of area sown more land utilization in India. This means that the series may be enough to produce stationary and there may be no need for additional moving average terms.

Table 6: Forecasted Values for the Next 10 Years

Year	Forecasted Values
2023	801.3541
2024	809.6179
2025	812.5215
2026	826.2030
2027	836.9056
2028	842.3608
2029	852.9158
2030	863.8317
2031	871.2003
2032	880.4658

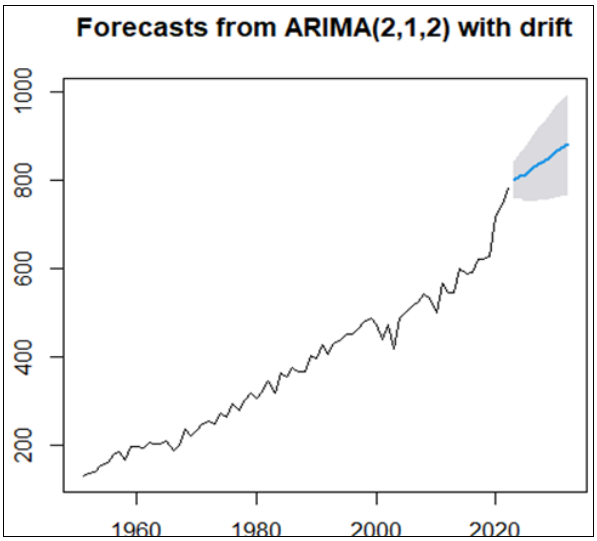

Fig 6: Forecast of Area Sown More than Once

In Table 6, an area sown more than once will see a notable increase of 12.66 per cent during the year 2023 to 2032 from 801.3541 ha to 880.4658 ha, showing a likely rise in the practice of double or multiple farming on the same land.
Fig. 6 shows the plot for an 11-year projection of the forecasting of Area Sown More than Once land utilization in India obtained by fitting the ARIMA (2,1,2) with drift best fit model to our time series data.

7) Total Cropped Area Forecast of India

ARIMA Model

ARIMA (2,1,2) with drift: Inf
ARIMA (0,1,0) with drift: 748.0222
ARIMA (1,1,0) with drift: 732.3133
ARIMA (0,1,1) with drift: 731.2973
ARIMA (0,1,0): 750.9944
ARIMA (1,1,2) with drift: 734.4323
ARIMA (0,1,1): 744.3693
Best model: ARIMA (0,1,1) with drift
AIC=731.3 BIC=738.09

The output above offers a selection of ARIMA models denoted by their parameters, AIC, BIC values and (p, d, q).
The ARIMA model with parameters (0,1,1) with drift has the lowest AIC value among the chosen options, so it is the best-fitting model for the forecast of total cropped land utilization in India. This implies that the series might be adequate to produce stationary values without the need for additional moving average terms.

Table 7: Forecasted Values for the Next 10 Years

Year	Forecasted Values
2023	2172.348
2024	2183.982
2025	2195.615
2026	2207.249
2027	2218.883
2028	2230.516
2029	2242.150
2030	2253.784
2031	2265.417
2032	2277.051

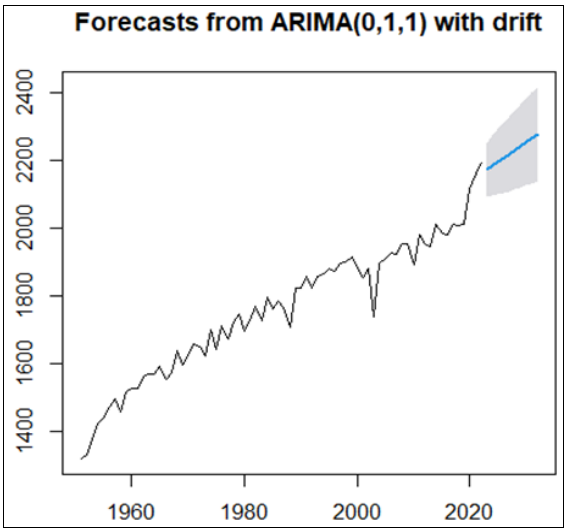

Fig 7: Forecast of Total Cropped Area

Table 7 shows that the total cropped area, which includes all land where crops are grown, is projected to increase by 3.90 per cent which goes from 2172.348 ha to 2277.051 ha during the period 2023 to 2032. This reflects an overall growth in agricultural activity.
Fig. 7 provides the plot for an 11-year projection of the forecasting of Total Cropped land utilization in India obtained by fitting the ARIMA (0,1,1) with drift best fit model to our time series data.

8) Cultivable Land Forecast of India

ARIMA Model

ARIMA (0,1,0): 559.3733
ARIMA (2,1,0): 553.612
ARIMA (1,1,0): 554.8867
ARIMA (3,1,0): 555.5203
ARIMA (2,1,1): 555.4186
ARIMA (1,1,1): 553.7617
ARIMA (3,1,1): 557.2501
Best model: ARIMA (2,1,0)
AIC=553.61 BIC=560.4

The output above offers a selection of approximate ARIMA models, denoted by their parameters (p, d, q) and it also provides their AIC and BIC values.
The ARIMA model with parameters (2,1,0) has the lowest AIC value for the forecast of cultivable land utilization in India, making it the best-fitting model. This means there may be no need for additional moving average terms and that the series may be enough to produce stationary.

Table 8: Forecasted Values for the Next 10 Years

Year	Forecasted Values
2023	1802.979
2024	1801.492
2025	1802.951
2026	1801.665
2027	1802.862
2028	1801.778
2029	1802.773
2030	1801.866
2031	1802.696
2032	1801.938

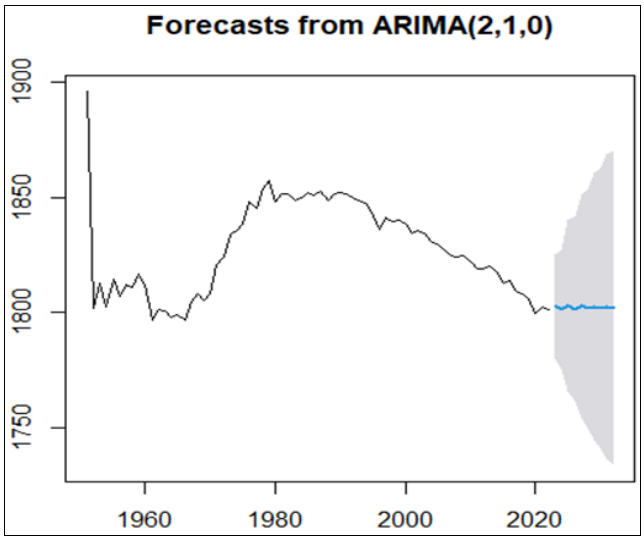

Fig 8: Forecast of Cultivable land

The area that is potentially suitable for cultivation will see a minor increase from 1802.979 ha to 1801.938 ha (0.05%) from 2023 to 2032 in Table 8.

Fig. 8 shows the plot for an 11-year projection of the forecasting of Cultivable land utilization in India obtained by fitting the ARIMA (2,1,0) best fit model to our time series data.

9) Cultivated Land Forecast of India

ARIMA Model

ARIMA (2,2,2): 489.2313
ARIMA (0,2,0): 521.3396
ARIMA (1,2,0): 496.7685
ARIMA (0,2,1): 487.3776
ARIMA (1,2,1): 487.7938
ARIMA (0,2,2): 487.726
ARIMA (1,2,2): Inf
Best model: ARIMA (0,2,1)
AIC=487.38 BIC=491.87

The output above presents a selection of approximate ARIMA models, denoted by their parameters (p, d, q) and their AIC and BIC values.

The ARIMA model with parameters (0,2,1) shows the lowest AIC value for the forecast of cultivated land utilization in India, which makes it the best-fitting model out of the other options. Hence the series might be enough to produce stationary values without the need for additional moving average terms.

Table 9: Forecasted Values for the Next 10 Years

Year	Forecasted Values
2023	1542.522
2024	1542.425
2025	1542.327
2026	1542.230
2027	1542.132
2028	1542.035
2029	1541.937
2030	1541.840
2031	1541.742
2032	1541.645

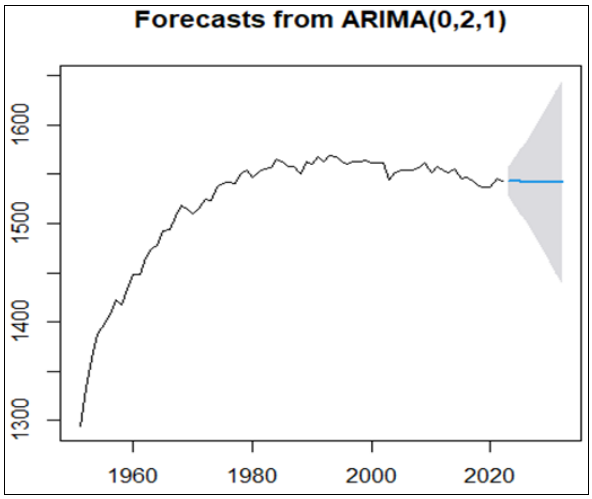

Fig 9: Forecast of Cultivated area

Table 9 provides the area that is actively cultivated will slightly decrease by 0.06 per cent which is about 1542.522 ha in 2023 to 1541.645 ha in 2032, which might be due to various factors such as changes in land use practices or environmental conditions.

Fig. 9 gives the plot for an 11-year projection of the forecasting of Cultivated land utilization in India obtained by fitting the ARIMA (0,2,1) best fit model to our time series data.

ARIMA Forecasting of Maharashtra

1) Forest Area Forecast of Maharashtra

ARIMA Model

ARIMA (2,1,2) with drift: Inf
ARIMA (0,1,0) with drift: 4.630664
ARIMA (1,1,0) with drift: 3.582007
ARIMA (0,1,1) with drift: 4.32553
ARIMA (0,1,0): 3.330385
ARIMA (1,1,1) with drift: 5.522027
Best model: ARIMA (0,1,0)
AIC=3.33 BIC=4.04

The output above presents a selection of approximate ARIMA models, denoted by their parameters (p, d, q), as well as their AIC and BIC values.

The ARIMA model with parameters (0,1,0) shows the lowest AIC value for the forecast of forest land utilization in Maharashtra, indicating that it is the best-fitting model among the options chosen. This shows that the series might be enough to produce stationary values without the need for additional moving average terms.

Table 10: Forecasted Values for the Next 10 Years

Year	Forecasted Values
2023	52.09001
2024	52.09002
2025	52.09003
2026	52.09004
2027	52.09005
2028	52.09009
2029	52.09010
2030	52.09015
2031	52.09018
2032	52.09019

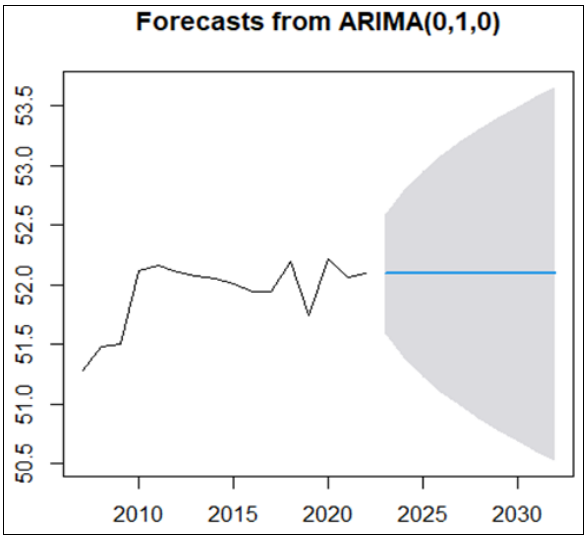

Fig 10: Forecast of forest area

In Table 10 we can see that the forest area is expected to remain stable, with no significant change anticipated up to 2032. This indicates that the forest cover will be maintained at its current level.

Fig. 10 depicts the plot for an 11-year projection of the forecasting of forest land utilization in Maharashtra obtained by fitting the ARIMA (0,1,0) best fit model to our time series data.

2) Not Available for Cultivation Area Forecast of Maharashtra

ARIMA Model

ARIMA (2,1,2) with drift: Inf
ARIMA (0,1,0) with drift: 36.86713
ARIMA (1,1,0) with drift: 38.405
ARIMA (0,1,1) with drift: 38.49752
ARIMA (0,1,0) : 44.16601
ARIMA (1,1,1) with drift: 40.0504
Best model: ARIMA (0,1,0) with drift
AIC=36.87 BIC=38.28

The above output provides selected tentative ARIMA models which are represented by its parameters (p, d, q), AIC values and BIC values.

For the forecast of not available for cultivation land utilization in Maharashtra, the ARIMA model with parameters (0,1,0) with drift exhibits the lowest AIC value, indicating it as the best-fitting model among the selected options. This suggests the series may be sufficient to achieve stationary and no further moving average terms.

Table 11: Forecasted Values for the Next 10 Years

Year	Forecasted Values
2023	37.86067
2024	38.53133
2025	39.20200
2026	39.87267
2027	40.54333
2028	41.21400
2029	41.88467
2030	42.55533
2031	43.22600
2032	43.89667

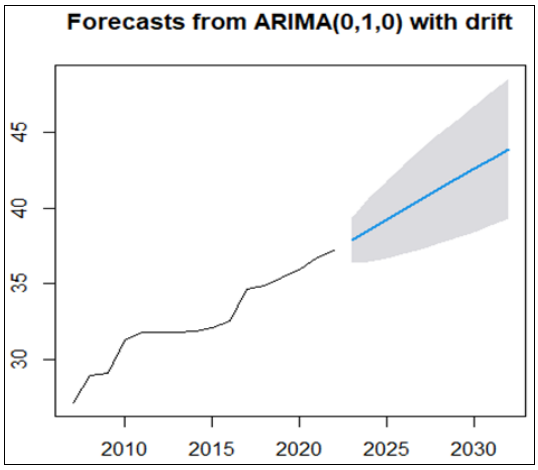

Fig 11: Forecast of Not Available for Cultivation Area

There will be a significant increase from 37.86067 ha to 43.89667 ha i.e. 18.03 per cent in the area that is non-available for cultivation in Table 11. This suggests that a larger proportion of land will become unsuitable for agricultural use, possibly due to urbanization, industrial development or environmental changes.

Fig. 11 gives the plot for an 11-year projection of the forecasting of Not Available for Cultivation land utilization in Maharashtra obtained by fitting the ARIMA (0,1,0) with drift best fit model to our time series data.

3) Fallow lands Forecast of Maharashtra

ARIMA Model

ARIMA (2,2,2): Inf
ARIMA (0,2,0): 46.88623
ARIMA (1,2,0): 45.58865
ARIMA (0,2,1): 45.40946
ARIMA (1,2,1): 46.7146
ARIMA (0,2,2): Inf
ARIMA (1,2,2): Inf
Best model: ARIMA (0,2,1)
AIC=45.41 BIC=46.69

Using its parameters (p, d, q), AIC values, and BIC values, the above output presents a selection of tentative ARIMA models.

The ARIMA model with parameters (0,2,1) shows the forecast of fallow land utilization in Maharashtra with the lowest AIC value, indicating that it is the best-fitting model among the options chosen. This shows that the series might be enough to produce stationary values without the need for additional moving average terms.

Table 12: Forecasted Values for the Next 10 Years

Year	Forecasted Values
2023	26.57395
2024	26.56790
2025	26.56186
2026	26.55581
2027	26.54976
2028	26.54371
2029	26.53766
2030	26.53162
2031	26.52557
2032	26.51952

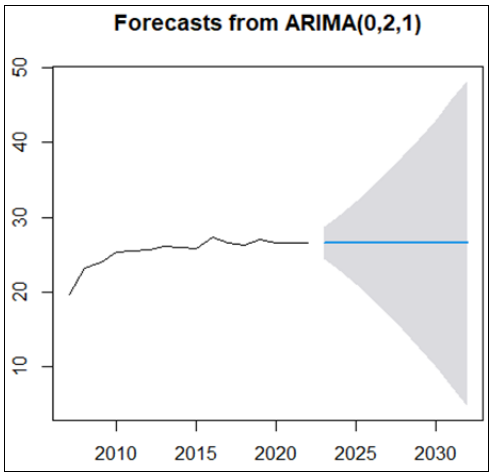

Fig 12: Forecast of Fallow land

From Table 12 the area of fallow land is projected to decrease by 0.23 per cent which is 26.57395 ha in 2023 to 26.51952 ha in 2032. This implies a slight reduction in the land left uncultivated for rest or regeneration.
Fig. 12 shows the plot for an 11-year projection of the forecasting of Fallow land utilization in Maharashtra obtained by fitting the ARIMA (0,2,1) best fit model to our time series data.

4) Area excluding Fallow lands Forecast of Maharashtra

ARIMA Model

ARIMA (2,1,2) with drift: Inf
ARIMA (0,1,0) with drift: 22.75771
ARIMA (1,1,0) with drift: 20.08444
ARIMA (0,1,1) with drift: 20.92482
ARIMA (0,1,0) : 21.8794
ARIMA (2,1,0) with drift: 21.92723
ARIMA (1,1,0) : 20.95925
Best model: ARIMA (1,1,0) with drift
AIC=20.08 BIC=22.21

The output above presents a selection of approximate ARIMA models, denoted by their parameters (p, d, q), as well as their AIC and BIC values.
The best-fitting model among the options chosen is the ARIMA model with parameters (1,1,0) with drift, which has the lowest AIC value for the forecast of area in Maharashtra that does not include fallow land utilization. This implies that the series might be adequate to produce stationary values without the need for additional moving average terms.

Table 13: Forecasted Values for the Next 10 Years

Year	Forecasted Values
2023	25.95062
2024	26.06586
2025	26.19383
2026	26.31542
2027	26.44020
2028	26.56339
2029	26.68737
2030	26.81095
2031	26.93474
2032	27.05842

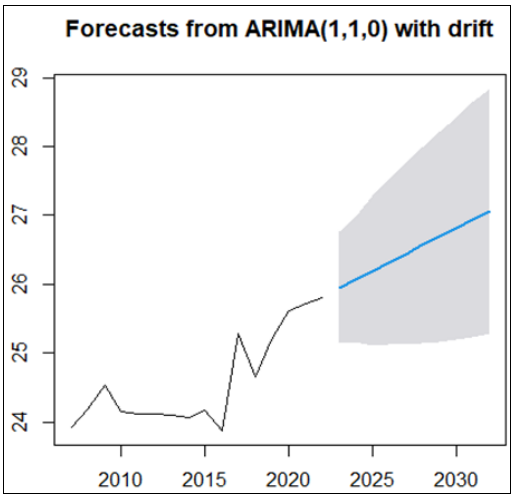

Fig 13: Forecast of Area excluding Fallow lands

Table 13 shows that there will be a notable increase from 25.95062 ha to 27.05842 ha (4.84%) in land excluding fallow land from the year 2023 to 2032. This indicates that more land will be actively utilized or potentially made available for cultivation, excluding the land set aside as fallow.
Fig. 13 reflects the plot for an 11-year projection of the forecasting of Area excluding Fallow land utilization in Maharashtra obtained by fitting the ARIMA (1,1,0) with drift best fit model to our time series data.

5) Net Sown Area Forecast of Maharashtra

ARIMA Model

ARIMA (2,1,2) with drift: Inf
ARIMA (0,1,0) with drift: 60.63586
ARIMA (1,1,0) with drift: 62.55679
ARIMA (0,1,1) with drift: 62.59786
ARIMA (0,1,0) : 66.40577
ARIMA (1,1,1) with drift: 64.24373
Best model: ARIMA (0,1,0) with drift
AIC=60.64 BIC=62.05

The output above offers a selection of approximate ARIMA models, denoted by their parameters (p, d, q), as well as their AIC and BIC values.
The ARIMA model for the forecast of net sown land utilization in Maharashtra with parameters (0,1,0) with drift has the lowest AIC value among the chosen options, making it the best-fitting model. This shows that the series might be enough to produce stationary values without the need for additional moving average terms.

Table 14: Forecasted Values for the Next 10 Years

Year	Forecasted Values
2023	164.5833
2024	163.2667
2025	161.9500
2026	160.6333
2027	159.3167
2028	158.0000
2029	156.6833
2030	155.3667
2031	154.0500
2032	152.7333

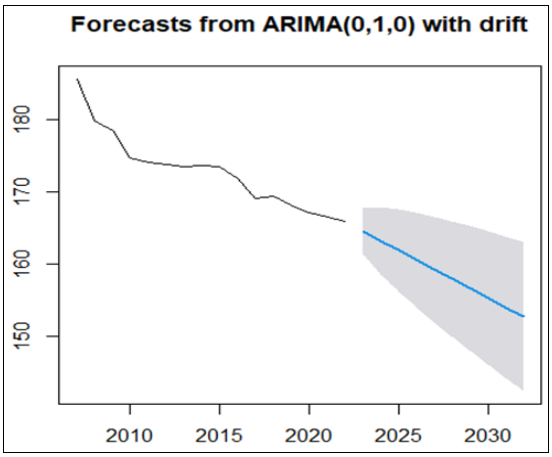

Fig 14: Forecast of Net Sown Area

In Table 14 it can be seen that the net sown area or the land actively used for crop cultivation, is expected to decrease by 7.94 per cent from about 164.5833 ha to 152.7333 ha. This indicates a reduction in the area of land that is actually sown with crops, which could reflect changes in agricultural practices or land availability.
Fig. 14 provides the plot for an 11-year projection of the forecasting of Net Sown land utilization in Maharashtra obtained by fitting the ARIMA (0,1,0) with drift best fit model to our time series data.

6) Area Sown More than Once Forecast of Maharashtra

ARIMA Model
ARIMA (2,1,2) with drift: Inf
ARIMA (0,1,0) with drift: 94.03393
ARIMA (1,1,0) with drift: 94.74369
ARIMA (0,1,1) with drift: 93.9817
ARIMA (0,1,0): 99.46493
ARIMA (1,1,2) with drift: Inf
ARIMA (0,1,1): 96.58474
Best model: ARIMA (0,1,1) with drift
AIC=93.98 BIC=96.11

The above output with parameters (p, d, q), AIC values and BIC values provides selected tentative ARIMA models.
The best-fitting model among the options chosen is the ARIMA model with parameters (0,1,1) and drift, which shows the lowest AIC value for the forecast of land utilization in Maharashtra that has been sown more than once. This indicates that the series may be sufficient to achieve no further moving average terms.

Table 15: Forecasted Values for the Next 10 Years

Year	Forecasted Values
2023	95.62847
2024	99.55062
2025	103.47277
2026	107.39492
2027	111.31707
2028	115.23922
2029	119.16137
2030	123.08352
2031	127.00567
2032	130.92782

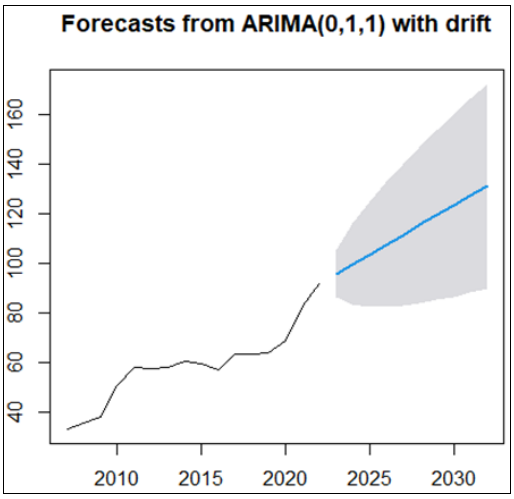

Fig 15: Forecast of Area Sown More than Once

Table 15 provides that there will be a significant increase from 95.62847 ha in 2023 to 130.92782 ha in 2032 (43.26%) in the area sown more than once. This suggests a strong rise in the practice of multiple farming, where the same land is used for growing more than one crop in a year.
Fig. 15 shows the plot for an 11-year projection of the forecasting of Area Sown More than Once land utilization in Maharashtra obtained by fitting the ARIMA (0,1,1) with drift best fit model to our time series data.

7) Total Cropped Area Forecast of Maharashtra

ARIMA Model
ARIMA (2,1,2) with drift: Inf
ARIMA (0,1,0) with drift: 93.3546
ARIMA (1,1,0) with drift: 93.41311
ARIMA (0,1,1) with drift: 90.98396
ARIMA (0,1,0): 95.22468
ARIMA (1,1,2) with drift : Inf
ARIMA (0,1,1): 90.92863
Best model: ARIMA (0,1,1)
AIC=90.93 BIC=92.34

The output above presents a few selected, approximate ARIMA models, each with its own set of parameters (p, d, q), as well as AIC and BIC values.
The ARIMA model with parameters (0,1,1) for the forecast of total cropped land utilization in Maharashtra shows the lowest AIC value, indicating that it is the best-fitting model. This shows that the series might be enough to produce stationary values without the need for additional moving average terms.

Table 16: Forecasted Values for the Next 10 Years

Year	Forecasted Values
2023	257.5781
2024	257.5781
2025	257.5781
2026	257.5781
2027	257.5781
2028	257.5781
2029	257.5781
2030	257.5781
2031	257.5781
2032	257.5781

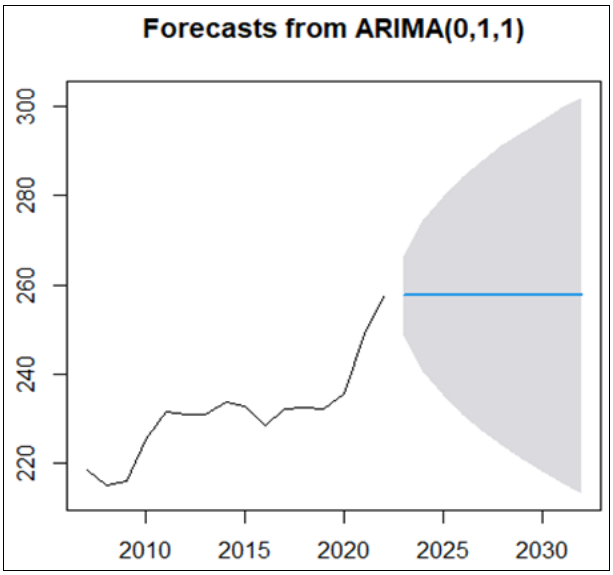

Fig 16: Forecast of Total Cropped Area

In Table 16, the total cropped area, which encompasses all land where crops are grown, will see a minimal increase of 0.11 per cent. This indicates a slight growth in overall agricultural activity but not substantial.
Fig. 16 gives the plot for an 11-year projection of the forecasting of Total Cropped land utilization in Maharashtra obtained by fitting the ARIMA (0,1,1) best fit model to our time series data.

8) Cultivable Land Forecast of Maharashtra
ARIMA Model
ARIMA (2,1,2) with drift: Inf
ARIMA (0,1,0) with drift: 76.76185
ARIMA (1,1,0) with drift: 78.34157
ARIMA (0,1,1) with drift: 77.83966
ARIMA (0,1,0: 78.20031
ARIMA (1,1,1) with drift: 79.58217
Best model: ARIMA (0,1,0) with drift
AIC=76.76 BIC=78.18

The output above presents a selection of approximate ARIMA models, denoted by their parameters (p, d, q), as well as their AIC and BIC values.
The ARIMA model with parameters (0,1,0) with drift has the lowest AIC value, making it the best-fitting model for the forecast of cultivable land utilization in Maharashtra. It suggests that the series might be enough to produce stationary values.

Table 17: Forecasted Values for the Next 10 Years

Year	Forecasted Values
2023	203.2713
2024	201.8827
2025	200.4940
2026	199.1053
2027	197.7167
2028	196.3280
2029	194.9393
2030	193.5507
2031	192.1620
2032	190.7733

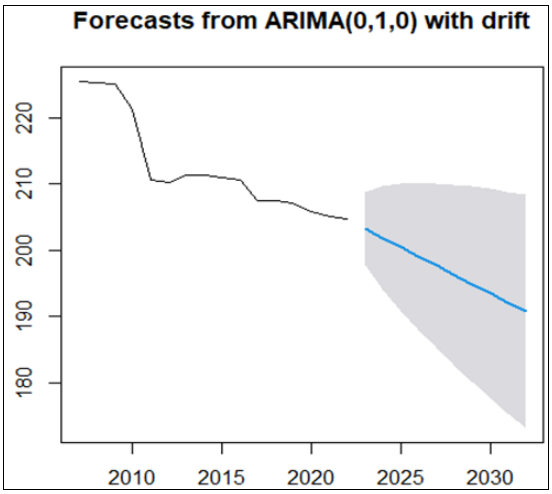

Fig 17: Forecast of Cultivable land

Table 17 shows that the area that seems suitable for cultivation is projected to decrease from 203.2713 ha in 2023 to 190.7733 ha in 2032 by 6.78 per cent. This reduction could be due to various factors such as land degradation, urban expansion or shifts in land use.
Fig. 17 gives the plot for an 11-year projection of the forecasting of Cultivable land utilization in Maharashtra obtained by fitting the ARIMA (0,1,0) with drift best fit model to our time series data.

9) Cultivated Land Forecast of Maharashtra
ARIMA Model
ARIMA (2,1,2) with drift: Inf
ARIMA (0,1,0) with drift: 41.48547
ARIMA (1,1,0) with drift: 43.46043
ARIMA (0,1,1) with drift: 43.45092
ARIMA (0,1,0): 45.93527
ARIMA (1,1,1) with drift: Inf
Best model: ARIMA (0,1,0) with drift
AIC=41.49 BIC=42.9

The above output provides selected tentative ARIMA models which are represented by their parameters (p, d, q), AIC values and BIC values.
For predicting the forecast of cultivated land in Maharashtra, the ARIMA model with parameters (0,1,0) with drift has the lowest AIC value, indicating that it is the best-fitting model among the options considered. This suggests that the series may be adequate for achieving stationarity and may not require additional moving average terms.

Table 18: Forecasted Values for the Next 10 Years

Year	Forecasted Values
2023	179.8403
2024	179.2215
2025	178.6028
2026	177.9841
2027	177.3653
2028	176.7466
2029	176.1279
2030	175.5091
2031	174.8904
2032	174.2717

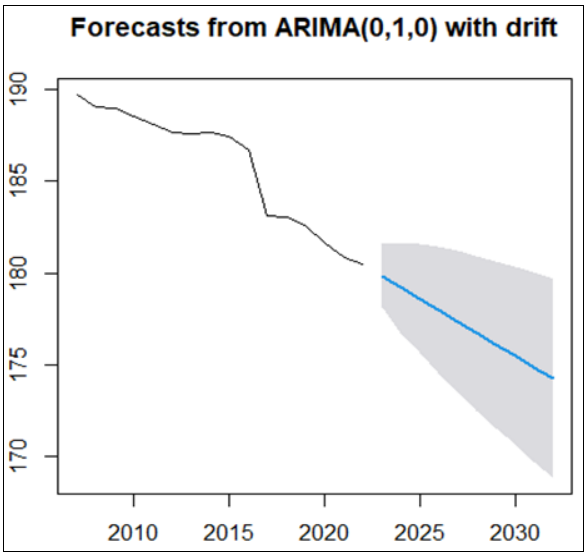

Fig 18: Forecast of Cultivated land

In Table 18 we can observe that the area that is actively cultivated will decrease by 3.43 per cent i.e. 179.8403 ha in 2023 to 174.2717 ha in 2032. This decrease might reflect a decline in the land being actively used for farming, possibly due to changes in agricultural trends or land availability.
Fig. 18 provides the plot for an 11-year projection of the forecasting of Cultivated land utilization in Maharashtra obtained by fitting the ARIMA (0,1,0) with drift best fit model to our time series data.

4. Conclusion

Land forecasting by using the ARIMA model shows that for India there is an overall increase in the net sown area, cropped area and the area sown more than once, there are also some reductions in specific land categories like non-available for cultivation and cultivated area. The changes suggest a complex shift in land use, with a slight increase in forest and fallow land but a significant decrease in land not available for continuous cultivation. In the case of Maharashtra state, there is a strong increase in the area sown more than once and a slight increase in the total cropped area, there are significant reductions in net sown area, cultivable area and cultivated area. Additionally, there is a considerable rise in the area non-available for cultivation, suggesting that land use is shifting away from traditional agriculture. It can be concluded that land being the most vital part of agriculture, needs to be focused and maintained by further studying land shifting and providing policies for land preservation under agriculture and forest to balance biodiversity.

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