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Modelling and Analysis of Trend and Forecast for Banana crop of Area, Production, Productivity and Productivity of water at Tihamah Plain of Hodeidah in West of Yemen

Jamil Hassan Abdullah

Assistant Professor, Chief department of vegetation production in Faculty of Agriculture, Hodeidah University.

***Corresponding author E-mail:** jmailashh@gmail.com*

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Abstract

Banana crop has a wide spread in Yemen, a production of crop is covered countries needed and a part of production has been exported to several arabic countries . total area occupied about 28 per cent and production is an 87,914 metric ton about 30 per cent of the totally of fruit in the Tihamah plain of Hodeidah. This work aims to modeling and analysis of trends and forecasting for banana crop, area, production. Productivity, productivity of water of 20 years from 2002 to 2021. Tihamah plain of Hodeidah located west of Yemen. The data secondary was collected from statistical handbook of agriculture in ministry of agriculture and irrigation of Yemen. To this work, three models of simple regression were compared to chosen the best fitted model in order for analysis, trends and forecast during 20 years between 2002 and 2021, several parameters were estimated and evaluated, R2, AdjR2, MAPE, RMSE, U-STATISTIC and TIC for each model. Also, CDVI and CV were done. The result indicated that the logarithmic model was the best fitted for analysis trends and forecast for production, productivity and productivity of water, is given by: Y= 14211ln(x)+36394, Y= 1.8379ln(x)+7.0126 and Y= -525.9ln(x)+3557.9 respectively, similarly linear model was the best for area is given by: Y= 37.53 × (x) + 3597.8. AGR, CV and CDVI were done. CDVI and CV, the study revealed that Low Instability, CDVI<15 and CV varied between 3.99 to 17.73%, for AGR recorded 1.28, 4.32, 3.17 and -3.00 for area, production, productivity and productivity respectively, this result revealed that there are future risks of water uses for banana crop irrigation, A forecast for next years of banana production can be used for plan demand to banana production and sustainable management of agricultural resources and ground water.

Keywords: *banana crop, modeling, CDVI, AGR, Trends, Forecast.*

1. Introduction

Amoxicillin (AMOX) is in the penicillin group of antibiotics, It is used to treat diseases resulting from bacterial infections, such as infections of the respiratory tract, as well as to treat infections of the middle ear, tonsillitis and throat, urinary tract, and skin. According to IUPAC, Amoxicillin known

Banana is one of the most important fruit crops across the world, oldest fruits to humanity and known as the Apple of paradise. It is tropical and sub-tropical crop and grown in over 130 countries, Banana is It is the second largest produced fruit after citrus, contributing about 16% of the world's total fruit production (FA0, 2009). Mainly cultivated for it Is ripen fruits, cooked vegetables and leaves in India and many other countries such as Yemen. Southeast Asia and southern China are the strongest candidate to be the primary sites to domestication (Al-Bsaidi, 2013). banana (Musa spp) from the family Musaceae" is one of the globally important tropical sub-tropical fruits all over the world and its name come from the Arabic word banana, which means finger (Sharma and Kispotta, 2017). Banana with round availability provide permanent of income not only to the farmers and rural population but also playing important role to poverty alleviation (Mustapha and kumar, 2012). In Yemen, crop banana has wide spread of cultivation since of 1984, the produce crop banana became cover of country's needed, and also, a part from quantity of the crop production is exported to several Arab countries such as Saudi Arabia, the United Arab Emirates, Oman, Jordan and Kumite. A banana crop cultivated widely all over the country. It represents about 11 per cent of the total area and the same per cent for production of fruit crops in Yemen, on the level of Tihamah plain of Hodeidah, total area occupied 6686 hectares about 28 per cent and production is 87,914 metric ton about 30 per cent of the totally of fruit in the Tihamah plain of Hodeidah. The major banana crop is farming in several regions(districts) of Yemen, Hodeidah, Lahj, Abyan, Taiz, Hadramout, Hajjah, Ibb, Al- Mahaweet, Shabwa and Dahmer. Yemen has a shortage of water, because water resources is limited, under groundwater is major resource to irrigation additional to all area under crop was used traditional irrigation such banana in Tihama plain of Hodeidah, this system lead to loss of water and decreasing of productivity of water, crop water requirement for banana crop under traditional irrigation was estimated of 25922 M3/ Ha (GSC,2008). An analysis, trend, forecasting, annual growth rate and instability index of crop fruit were studied by several researchers such (Sangolkar 2012); Sharma 2009); Sihmar 2014); (Rathod , 2021) Bhaskar and Nirban (2013) (Ahmad et al., 1973 1974; Islam and Hoque, 2005; Hoque, 2006; Roy et al., 2006; Ara et al., 2011; Mukul and Rahman, 2013; Mohiuddin et al., 2014; Hossain et al., 2015; Hossain et al, 2016; Ghimire et al. 2023; Varalakshmi et al, 2022; Kumari, et al, 2022). This research aims to modeling and analysis of Forecasting and trends for banana crop, of area, production. Productivity, productivity of water of 20 years from 2002 to 2021to 2021.

2. Methods and material

The study conducted to objective modeling and analysis trend and forecast of area, production. productivity, productivity of water banana crop at Tihamah plain of Hodeidah governorate, which located west of Yemen. The secondary data of study for a period of 20 years (2002-3021) in Tihama plain of Hodeidah

governorate west of Yemen was collected from sources of Ministry of Agriculture and Irrigation of Yemen, agricultural statistics year books year are used and adapted simple regression. Three models of simple regression were compared to selected the best model in order to trends and forecast, area, production, productivity and productivity of water, several parameters were estimated and evaluated for each one, R2, ADJR2, MAPE, RMSE, U-STATIC and TIC, also CDVI, CV were done to instability of trends, area, production, productivity and productivity of water, similarly annual growth rate (AGR) were done. Excel program was used for this work. To analyses the trend and forecast of area, production and productivity of water of banana crop, three model forms were compared they are given by:

Linear model: $\widehat{Y} = a + bx$

Exponential model: $\widehat{Y} = ab^{x}$

Logarithmic model: $\widehat{Y} = a + b\ln(x)$

Where:

$\widehat{Y}$= the area, production, productivity, productivity of water

X= time variable of year

a= intersect

b= coefficient of regression

2-1 Annual growth rate

The annual growth rate for each year was calculated for actual and trends of area, production, productivity and productivity of water of 20 years from 2002 to 2021. Annual growth rate was used (Hayes, 2021a), the formula is given by:

$$AGR = \frac{\text{value in } t^{th} \text{ year} - \text{value in } (t-1)^{th} \text{ year}}{\text{value in } (t-1)^{th} \text{ year}} \times 100$$

2-2 Coefficient of Determination (R^2) and AdjR^2

Coefficient of determination (R2) was done by three linear model, logarithmic model and exponential model for each one, Excel program was used for them. Whereas, AdjR2 was applied by Ramana and Babu (2018), it is given by:

$$\textbf{Adj R2} = 1 - (1-R2) \times \frac{n-1}{n-p-1}$$

where, n is the number of observations and p is the number of parameters in the model.

2-3 Coefficient of variation

$$CV = \frac{\text{standard deviation}}{\text{mean}}$$

2-4 Della Valle instability index (CDVI)

Several researchers (kihla et al, 2021; Hazarica et al, 2021; Cuddy and Della Vella, 1978) reported that the agriculture instability can be measured by different methods such as the coefficient of variation (CV) and Cuddy Della Valle Index (CDVI).

$$(CDVI) = CV\sqrt{1 - R^2}$$

Where:

Low Instability = 0<CDVI<15

Medium Instability = 15<CDVI<30

High Instability = CDVI>15.

2-5 Estimation and evaluation of the study parameters

Before predicting forecasting, the parameters were estimated and evaluated the parameters for each model were compared for selected the best fitted model for trend and forecast for banana crop, area, production, productivity and productivity of water at Tihamah plain of Hodeidah. AdjR2, MAPE, RMSPE, U-STAYISC and TIC. Murthy and Babu, (2013) they used Mean absolute percentage error (MAPE), Residual mean square error (RMSE) and U-Statistic. Mean absolute percentage error (MAPE) is given by:

$$MAPE = \frac{1}{n}\sum_{l=1}^{n}\left|\frac{Y - \widehat{Y}}{Y}\right| \times 100$$

Where: $Y =$ actual value, $\widehat{Y} =$ frcasted value, n= number of observations

The Interpretation of MAPE values (Lewis, 1982):

<10 highly accurate forecasting

10- 20 good forecasting

2- 50 reasonable forecasting

>50 inaccurate forecasting

Residual mean square error (RMSE) is given by:

$$RMSE = \sqrt{\frac{\sum_{1=t}^{n}(A_T - F_t)^2}{n}}$$

U- Statistics for agriculture analysis is given by:

$$U = \sqrt{\frac{\sum_{t=1}^{n-1}(F_{t+1} - Y_{t+1})^2}{\sum_{t=1}^{n-1}(Y_{t+1} - Y_t)^2}}$$

Where: F_{t+1}= is the forecasted value at time period (t+1); Y_{t+1} = is the actual value at the time (t+1); Y= is the actual value for the time (t); F= is the trend value for the time (t); n= is the number of observations For Interpretation of U values, if U<1 is the best trend and forecasting.

Inequality coefficient, inequality coefficient (TIC) (Theil, 1967) is given by

$$TIC = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{t}(\gamma_t^f - \gamma_t^a)}}{\sqrt{\frac{1}{t}\sum_{t=1}^{t}(\gamma_t^a)^2} + \sqrt{\frac{1}{t}\sum_{t=1}^{t}(\gamma_t^f)^2}}$$

Where: γ_t^f= trend values at the time (t), γ_t^a = actual values at the time (t), if TIC < 1 is better trend and forecasting

3. Results and Discussion

3-1 Analysis of actual values

Table 1 reveals that, the area and production have been increased from 5535 hectare to 6686 hectare, 41900 to 87914 MT respectively with 20 years from 2002 to 2021, in case The productivity has increased from 7.57 to 13.15Mt/Ha, whereas, productivity of water has been decreased from3424.3 to 1971.41M3/Mt of 20 years from 2002 to2021. On other hand, actual values for time series of 20 years from 2001-202, (table 1) shows, average of area (Ha), production (Mt), productivity (Mt/Ha), productivity of water (M3/Mt) were 6025.05, 66476.05, 10.90 and 2444.73, minimum value were 5535, 41900, 7.57 and 1971.41 respectively, maximum value were 6686, 87914, 13.15 and 3422.30 respectively.

Table 1 shows that there is an increase in the area of banana cultivation in Hodeidah the value of annual growth rate of 1.10% , 4.35, 3.29 and -2.72 for area, production, productivity and productivity of water respectively, the result presented there is higher value for banana crop of 4.35% and 3.29% of production and productivity respectively, on other hand, the growth in productivity of water has been negative value of -2.72% during the period of 20 years between 2002 to 2021, this indicated that loss of water by traditional irrigation which has been used. Furthermore, highest growth rate has been

observed in case of production, on other hand Annual growth rate of area presented low value of 1.10 is during of 20 years (Table 2) and (fig 1).

Table 1: data change of area, production, productivity and productivity of water for the period of 19 years from 2002 to 2021 at Hodeidah west of Yemen.

Year	Area (Ha) Actual	Actual production (Mt)	Actual productivity (Mt/Ha)	Actual productivity of water of water (M^3/MT)
2002	5535	41900	7.57	3424.3
2003	5535	41900	7.57	3424.3
2004	5535	41900	7.57	3424.3
2005	5670	45360	8.00	3240.25
2006	5680	62480	11.00	2356.55
2007	5850	66845	11.43	2268.59
2008	6152	71534	11.63	2229.32
2009	6326	73680	11.65	2225.6
2010	6275	74803	11.92	2174.52
2011	6286	74775	11.90	2179.15
2012	6271	73710	11.75	2205.36
2013	6235	73397	11.77	2202.05
2014	6211	69727	11.23	2309.03
2015	5994	69038	11.52	2250.59
2016	5946	69698	11.72	2211.43
2017	6021	65586	10.89	2379.72
2018	5901	70398	11.93	2172.87
2019	5901	77438	11.93	2172.83
2020	6491	77438	11.93	2072.41
2021	6686	87914	13.15	1971.41
Average	6025.05	66476.05	10.903	2444.729
Max	6686	87914	13.15	3424.3
Min	5535	41900	7.57	1971.41
AGR %	1.10	4.35	3.29	-2.72

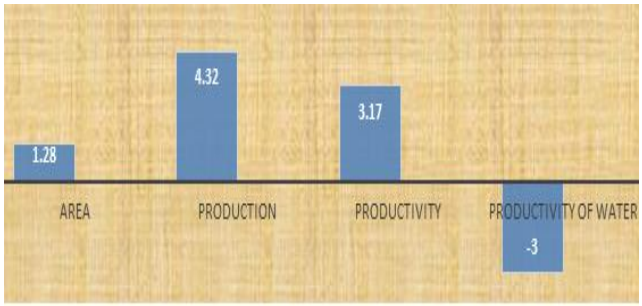

Fig 1: variation of AGR for actual value for area, production, productivity and productivity of water during 20 years from 2002 to 2021.

3-2 Estimation and evaluation of parameters

To selecting the best of models in order to analysis trend and forecasting of area, production, productivity and productivity of water for banana crop in Hodeidah, three model were compared based on maximum of adjusted R2, minimum of RMSE, MAPE, Theil's U-statistic and TIC. The results were presented in table 2,3,4,5,6.7,8,9,10 PROGRAM EXCEL was used.

Table 2: determine of model form for area, production, productivity and productivity of water of water by using logarithmic model

Aspect	Model
Area	$\hat{Y}$= 295.37ln(x)+5399.8
Production	$\hat{Y}$= 14211ln(x)+36394
productivity	$\hat{Y}$= 1.8379ln(x)+7.0126
productivity of water	$\hat{Y}$= -525.9ln(x)+3557.9

Table 3: determine of model formula for area, production, productivity and productivity of water by using exponential model

Aspect	Model
Area	$\hat{\hat{Y}}$= 5414,5*$x^{0,0498}$
Production	$\hat{Y}$= 38634*$x^{0,2438}$
Productivity	$\hat{Y}$= 7.1907*$x^{0.1901}$
productivity of water	$\hat{Y}$= 3620.5*$x^{0,193}$

Table 4: determine of model formula for area, production, productivity and productivity of water by using linear model

Aspect	Model
Area	$\hat{Y}$= 37.153*x+ 3597.8
Production	$\hat{Y}$= 1770.1*x+ 47889
productivity	$\hat{Y}$= 0.2215*x+8.3773
Productivity of water	$\hat{Y}$= -62.27*x+ 30986

Table 5: value of R2 under linear, exponential and logarithmic model for area, production, productivity and productivity of water

Aspect	linear	Compound	Logarithmic
Area	0.45	o.53	**0.53**
Production	0.63	0.74	**0.76**
Productivity	0.58	0.73	**0.76**
Productivity of water	0.56	0.77	**0.77**

Table 6: value of AdjR2 under linear, exponential and logarithmic functions for area, production, productivity and productivity of water

Aspect	Model		
	linear	Exponential	Logarithmic
Area	**0.39**	0.47	0.48
Production	0.66	0.72	**0.74**
Productivity	0.53	0.71	**0.73**
Productivity of water	0.51	0.74	**0.74**

Table 7: value of U under linear, exponential and logarithmic for area, production, productivity and productivity of water

Model	U			
	Area	Production	Productivity	Productivity of water
logarithmic	**1.1832**	**1.1267**	**0.9749**	**1.1193**
linear	1.3034	1.6886	1,2345	1.4995
Exponential	3.4541	7.8102	1.5524	18.00

Table 8: value of MAPE by linear, exponential and logarithmic model for area, production, productivity and productivity of water

Model	MAPE			
	Area	Production	Productivity	Productivity Water
logarithmic	4.45	**9.05**	**7.35**	**7.75**
linear	**3.6**	12.00	9.20	10.85
Exponential	8.94	60.46	16.15	144

Table 9: values of RMSE by linear, exponential and logarithmic model for area, production, productivity and productivity of water

Model	RMSE			
	Area	Production	Productivity	Productivity of water
logarithmic	214.99	**6320**	**0.8336**	**230**
linear	**76**	9236	1.0954	312
Exponential	632	47149	1,3674	3374

Table 10: values of TIC by linear, exponential and logarithmic model for area, production, productivity and productivity of water

Model	TIC			
	Area	Production	Productivity	Productivity of water
logarithmic	0.02296	**0.046**	**0.037**	**0.047**
linear	**0.01**	0.02	0.049	0.063
Exponential	0.09	0.26	0.061	0.40

3-3 Selecting of best fitted model

The best model was selected by maximum value of the parameters, AdjR2, and minimum value MAPE, RMSE, U-STATISTIC and TIC, the result of study reveals in table 11. The logarithmic model was the best model to analysis trend and forecast of production, productivity and productivity of water, whereas linear model was superior for area during 20 years between 2002 to 2021 at Tihama plain of Hodeidah.

Table 11: evaluated of parametrs for the best fitted model in base the manimu values of area production, productivity and productivity of water for time series of 20 years from 2002 to 2021in Hodeidah

Parameters	Area	Production	productivity	Productivity of water
$AdjR^2$	0.48	0.74	0.73	0.74
MAPE	4.45	9.05	7.35	7.75
RMSE	76	6320	0.8336	230
U-STATISTIC	1.183	1.1267	0.9749	1.1193
TIC	0.01	0.046	0.037	0.047

3-4 Analysis of trend on base the best fitted model

3-4-1 Trends in Area

The maximum value of adjusted R2 was 48% for minimum values of MAPE, RMSE, Theil's U-statistic and TIC were 4,45, 76, 1.1832 and 0.01 respectively. The result indicated that linear model has been best fitted to trend and forecast of area for banana crop. the data presented in table 11. we observed that there is an increasing for trend on area of banana crop during 20 years among 2002-2021 in Hodeidah. Linear model is given by (table 2):

$$\hat{Y} = 37.153 \times (x) + 3597.8$$

The actual values and trends area of banana during period of 20 years is revealed in Table 11. The graphical comparison between the actual values and trends of banana crop of area reveals that there are little variations which indicate that the linear model has well fitted to forecast for banana area of 20 years between 2002 and 2021 (fig 2).

3-4-2 Trends in production

The maximum value of adjusted R2 is 0.74%, minimum values of MAPE, RMSE, Theil's U-statistic and TIC are 9.05, 6320, 1.1267 and 0.046 respectively for logarithmic model. The data presented in Table 11, for production under the banana crop. logarithmic model was found to be the best trend equation for future forecast of production for banana crop. We have observed that there is an increasing trend on production of banana crop for time series of 20 years from 2002 to 2021. A logarithmic model is given by (table 2):

$$\hat{Y} = 14211\ln(x) + 36394$$

The actual value and trend production of banana by model during period of20 years from 2002 to 2021 are revealed in Table 12. The graphical comparison between the actual values and trends banana production reveals that, there is little variations which indicate that the logarithmic model has well forecast for banana productivity (fig 3).

3-4-3 Trends in productivity

On base of maximum value of adjusted R2 is 0.73%, minimum values of MAPE, RMSE, U-statistic and TIC are 7.35, 0.8336, 0.8749 and 0.037 respectively for logarithmic model (table 4). logarithmic model was appropriate for trends of productivity for banana crop. We have observed that there is an increasing trend of productivity during time series of 20 years from 2002 to 2021. The fitted logarithmic model is given by (table 2):

$$\hat{Y} = 1.8379\ln(x) + 7.0126$$

The actual value and trend productivity of banana crop were applied by logarithmic model during period of 20 years is revealed in Table 12. The graphical comparison between the actual values and trends banana crop of productivity reveals that, there is little variations which indicated that the logarithmic model has fitness for the forecast for banana productivity of 20 years between 2002 to 2021 (fig 4).

3-4-5 Trends in productivity of water

The maximum value of adjusted R2 is 0.74%, minimum values of MAPE, RMSE, U-statistic and TIC are 7.75, 230, 1.1193 and 0.047 respectively the data is presented in Table 4 that logarithmic model was the best fitted for trends of productivity of water for banana crop. The data in table 12 showed that there is a decreasing trend on productivity of water during 20 years between 2002 and 2021 of banana crop in Hodeidah. The logarithmic model is given by (table 2):

$$\hat{Y} = -525.9\ln(x) + 3557.9$$

The trends values of productivity of water for banana crop during period of 20 years, were done by logarithmic model, and there is a decreasing of trends values this observed in Table 12. The graphical comparison between the actual values and trends banana of productivity of water shows that there are little variations which indicated that the logarithmic model has capability forecasted for banana productivity of water (fig 5).

Table 12: trend values of area, production, productivity and productivity of water by using logarithmic model

Year	Actual area (Ha)	Area Trend value (Ha)	Actual Production (Mt)	Production Trend values (Mt)	Actual Productivity (Mt/Ha)	Productivity Trend of values (Mt/Ha)	Actual productivity of water (M^3/Mt)	Productivity of water trend (mt/^{3}values (m
2002	5535	5670.05	41900	36394.00	7.57	7.01	3424.3	3557.90
2003	5535	5705.21	41900	46244.31	7.57	8.28	3424.3	3193.37
2004	5535	5740.36	41900	52006.38	7.57	9.03	3424.3	2980.14
2005	5670	5775.51	45360	56094.63	8.00	9.55	3240.25	2828.85
2006	5680	5810.67	62480	59265.72	11.00	9.96	2356.55	2711.50
2007	5850	5845.82	66845	61856.69	11.43	10.30	2268.59	2615.61
2008	6152	5880.97	71534	64047.33	11.63	10.58	2229.32	2534.55
2009	6326	5916.12	73680	65944.94	11.65	10.83	2225.6	2464.32
2010	6275	5951.28	74803	67618.76	11.92	11.04	2174.52	2402.38
2011	6286	5986.43	74775	69116.04	11.90	11.24	2179.15	2346.97
2012	6271	6021.58	73710	70470.49	11.75	11.41	2205.36	2296.85
2013	6235	6056.74	73397	71707.01	11.77	11.57	2202.05	2251.09
2014	6211	6091.89	69727	72844.50	11.23	11.72	2309.03	2208.99
2015	5994	6127.04	69038	73897.64	11.52	11.85	2250.59	2170.02
2016	5946	6162.20	69698	74878.10	11.72	11.98	2211.43	2133.74
2017	6021	6197.35	65586	75795.26	10.89	12.10	2379.72	2099.80
2018	5901	6232.50	70398	76656.79	11.93	12.21	2172.87	2067.91
2019	5901	6267.65	77438	77469.07	11.93	12.31	2172.83	2037.85
2020	6491	6302.81	77438	78237.42	11.93	12.41	2072.41	2009.42
2021	6686	6337.96	87914	78966.35	13.15	12.51	1971.41	1982.44

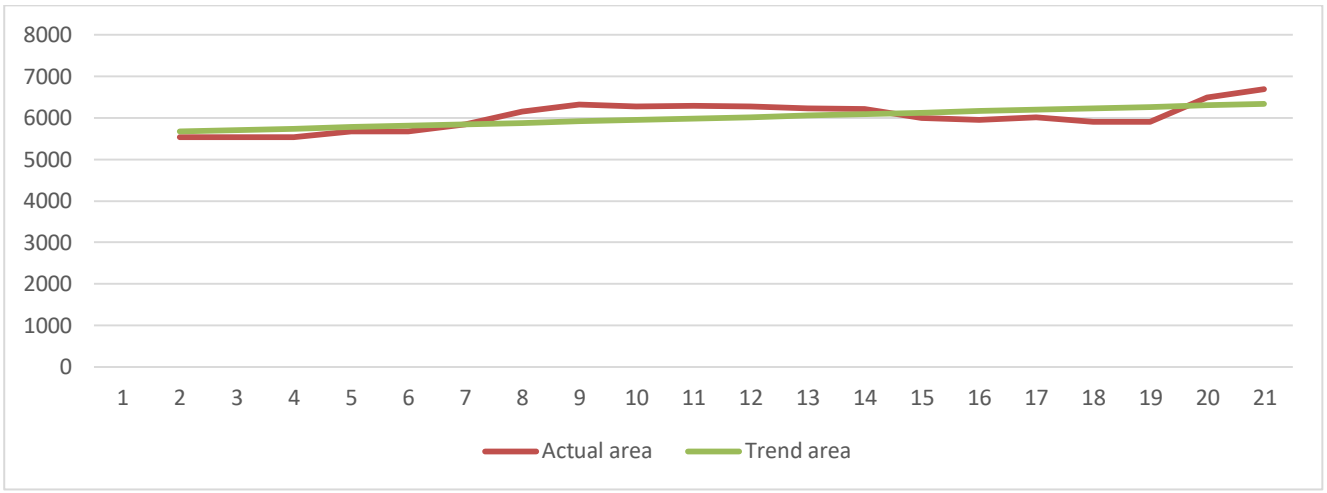

Fig 2: trends values of area by linear model for the period 0f of 20 years from 2002 to 2021. from 2002 to 2021 for Tihamah plain of Hodeidah

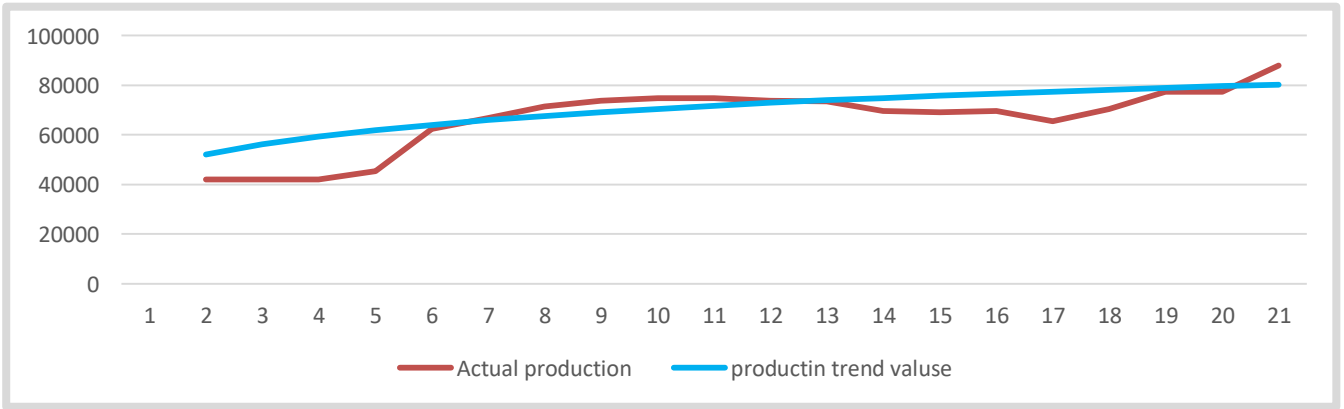

Fig 3: trends values of production for banana crop by model for the period 0f 10 years from 2002 to 2021 for Tihamah plain of Hodeidah.

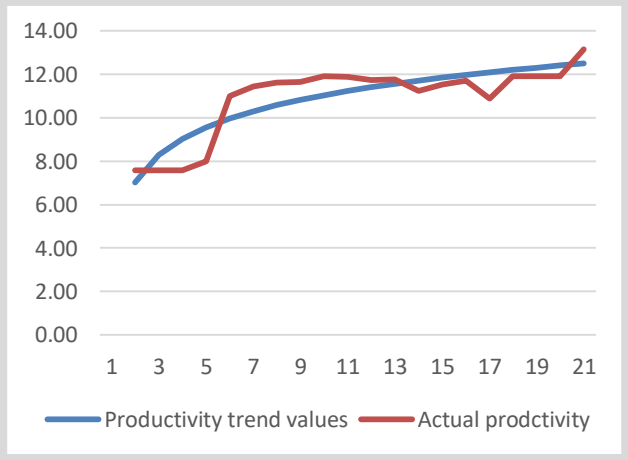

Fig 4: trends values of productivity of water for banana crop by logarithmic model for the period 0f 0f 20 years from 2002 to 2021 for Tihamah plain of Hodeidah.

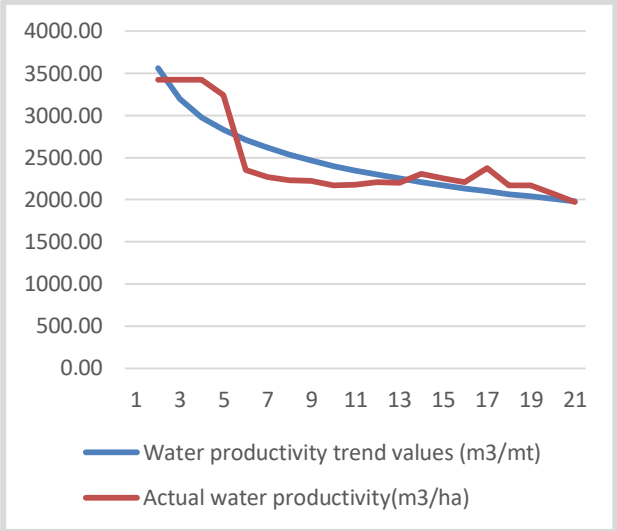

Fig 5: trends values of water productivity of water for banana crop by for the period 0f 20 years from 2002 to 2021 for Tihamah plain of Hodeidah

3-4-6 Trends of annual average growth rate (AGR)

The table 11and fig 6 show that there is an increase in the area of banana cultivation in Hodeidah, the value of annual growth rate of area recoded 1.1% of 20 years between 2002 and 2021, also they show an upward trend at the rate of 4.32% and 3.17% of production and productivity respectively, Highest annual growth rate has been observed in case of production, on other hand at productivity of water was decreased to -3% this indicated that there is loss of water by traditional irrigation, as a result there are future risks of water use for banana crop irrigation . fig 6 shows that there is a little different between of trends and actual values of AGR for 20 years from 2002 to 2021, it means that the forecast will be good for the future.

Table 11: trends of AGR% of area of banana crop for the period of 20 years from 2002 to 2021) at Hodeidah in Yemen

Aspect	Area	Production	Productivity	Productivity of Water
`AGR %	1.28	4.32	3.17	-3.00

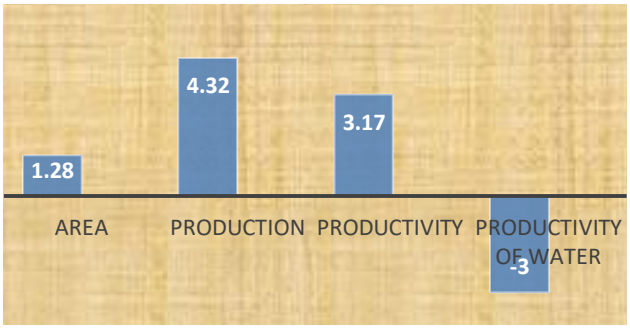

Fig 6: trends of AGR for area, production, productivity, productivity of water during 20 years between 2002 to 2021

3-5 Calculate of instability index

For instability of trend values was done by CDVI and CV, the study revealed that Low Instability of trend data, CDVI<15, for the CV we have observed that the varied were low values between 3.99 to 17.73% (Table 12).

Table 12: estimated of CDVI and CV for trend values of time series of area, production, productivity of water and productivity of water of water to 20 years (2002-2021)

Aspect	Area	Production	Productivity	Productivity of Water
CV	3.99	17.73	13.86	17.48
CDVI	3	12	10	13

3-6 Forecasting for banana crop of area, production, productivity and productivity of water for banana crops during next years at Tihamah plain of Hodeidah

Based on maximum value coefficient of determination R2, AdjR2, and minimum values, AdjR2, MAPE, RMSE, U-STATISTIC, and TIC, the best-fitted model was logarithmic model to forecast of production, productivity and productivity of water of banana crop during the period of next 13 years from 2022 to 2035, whereas forecast of area was done by linear model. Table 13 shows that, the forecasted area under banana will be has been increased between 6319.90 to 6449.70 Ha. Similarly, an increasing can also be showed in production from 79659.71to 86507Mt, whereas, productivity will be increased from 12.60 to 13.48 Mt/Ha, on other hand we can be observed that productivity of water will be decreased from 1956.79 to 1703.39 M3/ Mt.

Table 13: Forecasted area, production and productivity of banana crop in Tihamah plain in Tihamah plain of Hodeidah for next 13 years.

Year	Area	Production	Productivity	Productivity of Water
2022	6319.90	79659.71	12.60	1956.79
2023	6332.43	80320.80	12.68	1932.32
2024	6344.41	80952.51	12.76	1908.94
2025	6355.87	81557.32	12.84	1886.56
2026	6366.87	82137.44	12.92	1865.09
2027	6377.43	82694.81	12.99	1844.47
2028	6387.60	83231.14	13.06	1824.62
2029	6397.40	83747.96	13.12	1805.49
2030	6406.85	84246.64	13.19	1787.04
2031	6415.98	84728.42	13.25	1769.21
2032	6424.81	85194.39	13.31	1751.97
2033	6433.37	85645.57	13.37	1735.27
2034	6441.65	86082.87	13.42	1719.09
2035	6449.70	86507.11	13.48	1703.39

4. Conclusion and future trends

This paper was concentrated to analysis the trend and forecasting for area, production and productivity of banana crop at Tihamah plain of Hodeidah located west Yemen. this study was used secondary data were collected from book hand statistical of ministry of agriculture and irrigation of Yemen, for this purpose three models were compared linear, exponential and logarithmic model. Several parameters were estimated and compared on base maximum R2, AdjR2 values and minimum values of MAPE, RMSE, U-STATISTIC and TIC for three models, The parameters values of logarithmic model were superior of production, productivity and productivity of water they are given by: $\hat{Y}$=14211ln(x)+36394, $\hat{Y}$=1.8379ln(x)+7.0126 $\hat{Y}$=-525.9ln(x)+3557.9 respectively , whereas, linear model was suitable for area is given by: $\hat{Y}$= 37.153× (x) + 3597.8 , the trend values, area, production, productivity have been increased during 20 years between 2002 to 2021, on other hand, a value of productivity of water has been decreased. Similarly, an annual growth rate for area, production, productivity has been increased but the values of productivity of water has been decreased. Also, the forecast of area, production, productivity and productivity of water was done for 13 years. For instability of trend values was done by CDVI and CV, the study revealed that Low Instability, CDVI<15 and the CV was low values between 3.99 to 17.73%. Also, the result reveals that Trends of annual average growth rate recorded 1.28, 4.32, 3.17 and -3.00 for area, production, productivity and productivity of water respectively this result indicated that there are future risks for productivity of water uses for banana crop irrigation. Finally, can be gave some recommendation such as:

1) Can be used Logarithm model for forecast of the banana crop to plan's demand of production and sustainable management of agricultural resources and ground water uses in Tihama plain of Hodeidah and country.
2) Support the farmers of banana crop to agricultural input and extension in order to
3) Improvements productivity of banana crop.
4) Encourage farmers to use modern irrigation systems for banana crop irrigation.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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