Double Exponential Smoothing Forecasting Food Crop Yields Using Geographic Information Systems

Dovel Pirmanto

Islamic Library and Information Science Study Program, Faculty of Adab and Dakwah

Institut Agama Islam Negeri Kerinci

Kerinci, Indonesia

dovelpirmanto16@gmail.com

Abstract— **Food is a source of basic needs for every living creature, so food security is an interesting issue for every country. This raises problems regarding food and land use, especially in Sungai Penuh City. Food problems arise due to a lack of information regarding appropriate land use and the productivity of the land itself. In the current industrial era 4.0, forecasting can be done using information technology tools that provide convenience and efficiency in forecasting times and can be integrated with geographic information systems. The forecasts made by the community are based on past experience without considering the factors that influence crop yields, so that they can cause losses both in terms of time and costs. Apart from that, less accurate predictions of food yields can lead to less than optimal development of food security which has an impact on meeting food needs. This research involved respondents from the Department of Agriculture and Food Security, namely agricultural and food experts. The method for collecting data in this research is observation and interviews. This research analyzes harvest data for the 2018-2023 period sourced from the Central Statistics Agency using the Double Exponential Smoothing method by considering error values with $\alpha = 0.1$ and 0.5 and $\beta = 0.1$ and 0.5. The calculation of the smallest error value is: ME = 80.92, MAD = 5.58, MAPE = 11%, MSE = 52.69 by combining the value of $\alpha = 0.1$ and the value of $\beta = 0.1$ to produce a prediction of the corn harvest in Kumun Debai District in 2024 of 45 tons and year 2025 as much as 40 tons.**

Keywords— *Double Exponential Smoothing, Forecasting, Crops, Geographic Information Systems.*

I. INTRODUCTION

Food is a source of basic human needs which continues to increase from year to year. So this is an important challenge for every country, because the human population reaches nine billion people. The increasing need for food in Sungai Penuh City raises problems related to land use. This problem arises due to a lack of information regarding the level of land productivity and land suitability as food land. In addition, the low accuracy of food yield predictions can guarantee less than optimal food security, which has an impact on meeting food needs, resulting in the need for food assistance from other areas to meet food needs in Sungai Penuh City.

Currently, forecasting can use information technology to facilitate data processing with the help of automatic systems. Before the development of technology related to forecasting, forecasting was still done manually without looking at previous data or was more qualitative but not quantitative. [1]. Forecasting is a branch of science that discusses possible future events using mathematical calculations involving historical data. Various forecasting methods provide a structured way of analyzing data so that data analysis becomes better. The use of these data analysis techniques is expected to provide more accurate analysis results by testing deviations from the stored analysis data [3]. One method for making estimates is double exponential smoothing (DSE).

Technological developments really help people in obtaining information, one of the information needed is geographical information. The public can utilize this geographic information for various fields such as agricultural distribution, regional planning, research, mapping and other purposes. Geographic information is able to present data processing results that are integrated with spatial and non-spatial data. Various previous studies have developed and utilized Geographic Information Systems to support decision making in mapping agricultural land which has shown good results, this is supported by integration between GIS and decision support systems [9]. Sustainable use of Geographic Information Systems in the analysis of agricultural land use data that combines biophysical aspects, economic impacts and social impacts that arise in the northern Sinai region [10].

Based on the problems described above, it is very necessary to predict crop yields in order to minimize the impact of losses in both time and costs if incorrect crop yield predictions will be detrimental to farmers. So it is necessary to forecast agricultural yields to determine the productivity of land use in Sungai Penuh City, especially food crops. Previously, forecasting had not been integrated with geographic information systems so that forecasting results were only in the form of tables and graphs. It is deemed necessary for researchers to integrate forecasting results with geographic information systems so that it is easier to see prediction results displayed visually in the form of map polygons on the Geographic Information System and different legends for each land. The method used in this research is double exponential smoothing, namely the application of the double exponential smoothing method to predict crop yields in an integrated manner with a geographic information system. Based on

previous research, the use of the double exponential smoothing method is very appropriate for predicting annual data and this method takes into account various factors that influence the prediction results. So the results of calculations using double exponential smoothing can be mapped using GIS.

II. RESEARCH METHODOLOGY

The first stage of this research is data collection which is the initial stage to be able to estimate harvest yields. collecting data from various sources and literature as well as secondary data on harvest results for 2018-2023 from the Central Statistics Agency. The data collection method in this research is observation and interviews with agricultural and food experts to determine the research sample. The second stage is a literature study that collects information from various relevant and scientific sources to support the application of the prediction method. The third stage after data collection and literature study is data analysis using the double exponential smoothing method to predict agricultural results by paying attention to the standardization of each component that influences the prediction results.

The fourth stage analysis of system requirements is carried out so that the forecasting system that is the output of this research meets needs. The fifth stage in this research is system design which refers to the results of the system requirements analysis. This design is carried out to create a system in accordance with the results of the needs analysis. The sixth stage in this research is system testing to find out whether the system has deficiencies or not, so that users will find it easier to use the system. The seventh stage in this research is the implementation of the system that has been created. This implementation is carried out to find out whether this system can predict or not.
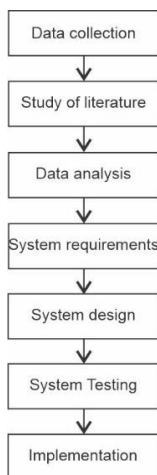

Figure 1. Research Methodology

A. Forecasting

Forecasting possible future events, based on science and consideration of data obtained in the past which has been stored as a data base. Utilization of previous data as a reference source to enable future events or data mathematically [4]. Forecasting is next is a quantitative forecasting method that predicts future data as the function of past data [18]. Predict future events based on past patterns and use policies against projections with past patterns [22][23].

Forecasting is a statement regarding the future value of a variable such as demand. This means that a forecast is a prediction about the future [5]. One branch of science in projecting possible future events is forecasting. The use of historical data as a reference tool for forecasting next year's sales based on historical sales data from the previous year using mathematical science [3]. electricity demand forecasting problems and is used for forecasting palm oil production [16], Inventory Forecasting [17][24], resource prediction over cloud computing [21], Forecasting Method for Small/medium Sized Hydropower Plants in Spot Market [25].

B. Forecast Model

Forecast models provide a more orderly and focused way of working, so that better analysis techniques are obtained, which can be expected to be able to provide greater trust or confidence, because they can be tested and scientifically proven deviations or deviations that occur. There also exist other categories of forecasting approaches, including the average approach [19], AI-based method [20]. Based on their nature, forecasts are divided into two, namely:

1) Quantitative Approach

Quantitative approach is a prediction that is based on a party's opinion and the data cannot be represented strictly as a number or value. A person who compiles the results of forecasting data analysis using one of the mathematical methods is one of the determining factors for the results of forecasting analysis.

2) Qualitative approach

Qualitative approach is a forecast that is based on past quantitative data and can be made in the form of numbers which can be called time series data which has a relationship with one or more variables that influence it.

To make a forecast, first determine the forecast period that will be carried out. Based on the forecast time, it can be grouped into three categories [3] namely:

1) Short Term Forecast

Short term forecasts can be classified as forecasts for a period of less than three months. These forecasts are usually used to plan purchases, work scheduling, sales, number of workers, and production levels.

2) Medium Term Forecast

Medium term forecasts can be classified into forecasts for a period of three months to three years. Medium-term forecasts are used for sales planning, production planning and budgeting, cash budgets and analyzing various operating plans.

3) Long Term Forecast

Long term forecasts can be classified as forecasts for a period of more than three years. Medium-term forecasts are used to plan new products, capital expenditures, location, or facility development and research and development.

C. Exponential Smoothing

Exponential Smoothing is a procedure for continuous improvement in forecasting the latest observation objects. He emphasizes the exponential decrease in priority for older observation objects. In other words, recent observations will be given higher priority for forecasting than older observations. There are several methods that are grouped into the Exponential Smoothing method, namely:

1) Single Exponential Smoothing

Simple exponential smoothing is another term for single exponential smoothing which is used for short-term forecasting analysis, namely forecasting for monthly data. Single exponential smoothing assumes that data will remain at the fluctuation of its mean value. Here's the formula:

$$F_t + 1 = \alpha X_t + (1-\alpha) F_t \tag{1}$$

Theory the value of $\alpha = 0.1$ or 0.5 or 0.9 (depending on the problem and achieving the desired results)
Contoh : Ft (feb + 1)=0,1 . 9265 + (1-0,1) 9325 Ft Maret = 9319
Ft = Forecast value for the t-th time period
Ft-1 = Forecast value for the past time period, t-1 Xt + (1-α) = Actual time series value

2) Double Exponential Smoothing

The use of the double exponential smoothing method looks at aspects of historical data sets that have a trend. In this method, there are two attributes that are always updated, namely level and trend. So this method adds two attributes at the analysis stage, namely level (α) and trend (β).

$$A_t = \alpha Y_t + (1-\alpha)(A_{t-1} + T_{t-1}) \tag{2}$$
$$T_t = \beta (A_t - A_{t-1}) + (1-\beta) T_{t-1} \tag{3}$$
$$F_{t+m} = A_t + T_t m \tag{4}$$

At = exponential smoothing value
α = smoothing constant for data ($0 < \alpha < 1$)
β = smoothing constant for trend estimation ($0 < \beta < 1$)
Yt = actual value in period t
Tt = trend estimation
F(t+m) = Forecast value

3) Triple Exponential Smoothing

This method is a development of the two previous methods which only involve level and trend factors, but this method adds a seasonal factor (γ) so that this method has two derivatives that take into account the type of season, namely:

- Multiplicative Seasonal Model
- Additive Seasonal Model

The difference between the Multiplication Seasonal Model and Additive Seasonal is as follows:

The Multiplicative Seasonal Model is multiplying the results of level and trend calculations with Seasonal calculations. Meanwhile, the Additive Seasonal Model is adding the results of level and trend calculations with Seasonal calculations. But what will be discussed here is only Triple Exponential Smoothing with the Multiplicative Seasonal Model.

$$A_t = \alpha \frac{Y_t}{S_{t-L}} + (1-\alpha)(A_{t-1} + T_{t-1}) \tag{5}$$
$$T_t = \beta (A_t - A_{t-1}) + (1-\beta) T_{t-1} \tag{6}$$
$$S_t = \gamma \frac{Y_t}{A_t} + (1-\gamma) S_{t-l} \tag{7}$$
$$Y_{t+p} = (A_t + T_t p) S_{t-L-p} \tag{8}$$

At = exponential smoothing value
a = smoothing constant for data ($0 < a < 1$)
b = smoothing constant for trend estimation ($0 < b < 1$)
m = smoothing constant for seasonal estimation ($0 < m < 1$)
Yt = actual value in period t
Tt = trend estimation
St = seasonal estimates
L = the length of the season
p = the number of future periods that will be forecast

D. Measurement Error

These measures can be used to compare different forecasting models, along with monitoring forecasts to ensure that they are working properly. The three most well-known measures are mean absolute deviation (MAD), mean squared error (MSE), and mean absolute percent error (MAPE). But here the average error (ME) will be added as the first reference for finding the error value.

1) ME (Mean error) or Average Error Value

$$ME = \frac{\sum Actual - Forecasting}{n} \tag{9}$$

2) MAD (Mean Absolute Deviation) or Absolute Error Average Deviation Value

$$ME = \frac{\sum |Actual - Forecasting|}{n} \tag{10}$$

3) MSE (Mean Square Error) or Mean Squared Error Value

$$MSE = \frac{\sum |Actual - Forecasting|2}{n} \tag{11}$$

4) MAPE (Mean Absolute Percent Error or Average Value of Percentage Error)

$$MAPE = \frac{\sum_{i-1}^{n} |Actual - Actual| / Actual}{n} \tag{12}$$

E. Geographic Information System

GIS is a system that is capable of analyzing data from data input, data processing, to producing output in the form of spatial data which is generally displayed in geographic form. Any data that refers to a location on the earth's surface can be called spatial data, for example population density data in an area, road network data in a city, data on the distribution of sampling

locations, and so on [6]. GIS consists of a combination of database management in collecting and storing large amounts of geospatial data, to determine the relationship between the entities of each data used, plus map layers which function to describe geospatial data relationships in two and three dimensions in the form of maps. [8].

GIS basically consists of 3 data processing parts related to an input process, process, report of analysis results which are the result of management and processing of the data [15]. The reason GIS is needed is because it is very difficult to handle spatial data, especially because maps and statistical data quickly become outdated so that there is no service to provide more effective data and information. [6]. Database Management System (DBMS) is a sub-system used to organize spatial and attribute data into a database so that it is easy to call, update and delete for data processing needs [7].

In general, a Geographic Information System consists of four main components, namely [10]:

1) Data, basic materials that can be processed or processed into information that has meaning so that it is useful to use. The data used in GIS is divided into two, namely spatial data and non-spatial data.
2) Hardware, is a physical device in the form of a computer and its supporting instruments.
3) Software is a module system that functions to operate GIS.
4) Use includes human resources or human intelligence (brainware).

III. RESULTS AND DISCUSSION

A. Research Stages

The first stage of this research is data collection which is the initial stage to be able to estimate harvest yields. collecting data from various sources and literature as well as secondary data on harvest results for 2018-2023 from the Central Statistics Agency. The data collection method in this research is observation and interviews with agricultural and food experts to determine the research sample. The second stage is a literature study that collects information from various relevant and scientific sources to support the application of the prediction method. The third stage after data collection and literature study is data analysis using the double exponential smoothing method to predict agricultural results by paying attention to the standardization of each component that influences the prediction results.

The fourth stage analysis of system requirements is carried out so that the forecasting system that is the output of this research meets needs. The fifth stage in this research is system design which refers to the results of the system requirements analysis. This design is carried out to create a system in accordance with the results of the needs analysis. The sixth stage in this research is system testing to find out whether the system has deficiencies or not, so that users will find it easier to use the system. The seventh stage in this research is the implementation of the system that has been created. This implementation is carried out to find out whether this system can predict or not.

B. Design

At the application design stage there are several processes that will be carried out starting from the system workflow to the system database, namely as follows:
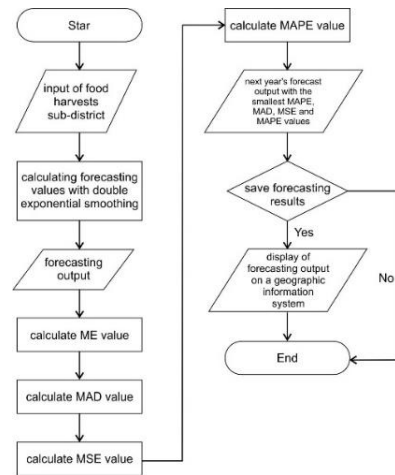
1) Flowchart

Figure 2. Flowchart of the Double Exponential Smoothing Forecast System

Based on the flowchart above it can be explained as follows:

- Enter harvest data to look for the alpha value
- Calculate forecasting values
- Displays forecasting results
- Calculating the Mean Error (ME) value
- Calculate the Mean Absolute Deviation (ME) value
- Calculate the Mean Percentage Error (MAPE) value
- Calculate the Mean Square Error (MSE) value
- Displays the output of estimated harvest results for the following year. Next save the forecast, otherwise it's done.
- geografis untuk setiap kecamatan. Kemudian selesai Displays the estimated harvest results in the geographic information system for each sub-district. Then it's done.
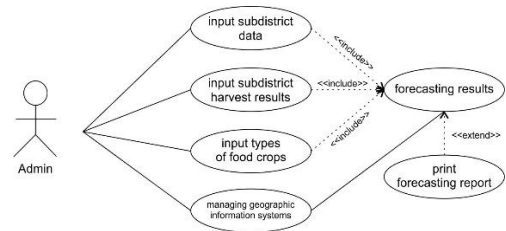
2) Use Case

Figure 3. *Use Case* Diagram

The use case diagram describes the activities that admins can carry out in a forecasting system with a geographic information system, namely:

- Admin can add data for each sub-district in Sungai Full City, as well as edit data and delete data.
- Admin can input, delete and edit plant type data.

- Admin can input, delete and edit harvest data for each sub-district.
- Admin can manage geographic information systems.
- Admin can see forecast results that have been processed using the double exponential smoothing method and can print forecast results reports. Admin can see forecast results on the geographic information system.

C. Double Exponential Smoothing Calculation

This research was conducted in Sungai Penuh City, Jambi Province with secondary data from 2018 to 2023.

TABLE I. RICE FIELD PRODUCTS /(TON)

Subdistrict	2018	2019	2020	2021	2022	2023
Tanah Kampung	13823	14211	10082	12432	16790	16299
Kumun Debai	4905	4548	7400	5524	10197	9874
Sungai Penuh	17842	12270	10727	13205	4272	4953
Pondok Tinggi	0	6140	9181	7780	10863	8958
Sungai Bungkal	0	5821	8372	7949	5494	9889
Hamparan Rawang	1952	0	0	0	1584	11866
Pesisir Bukit	4767	0	0	0	6208	7669
Koto Baru	0	0	0	0	2871	5984

Source : BPS Kota Sungai Penuh

TABLE II. CORN HARVEST RESULTS /(TON)

Subdistrict	2018	2019	2020	2021	2022	2023
Tanah Kampung	11	15	76	108	83	0
Kumun Debai	43	47	58	44	41	49
Sungai Penuh	76	144	108	105	8	11
Pondok Tinggi	0	19	25	0	11	103
Sungai Bungkal	0	0	40	0	0	92
Hamparan Rawang	3	0	0	0	124	22
Pesisir Bukit	84	0	0	0	8	22
Koto Baru	0	0	0	0	0	0

The initial step of this forecasting system is to input data on harvest results each year based on plant code, plant name and number of harvests (actual value). The next process is calculating the forecast value using the forecast method (double exponential smoothing). The following are the results of the forecasting calculations.

1) Estimated Rice Harvest Results for Tanah Kampung District

TABLE III. RESULTS OF CALCULATION OF DOUBLE EXPONENTIAL SMOOTHING RICE DISTRICT TANAH KAMPUNG

Year	Actual/ton	Forecast /ton
2018	13823	-
2019	14211	13823
2020	10082	14075
2021	12432	11537
2022	16790	11578
2023	16299	14559

TABLE IV. CALCULATION RESULTS OF THE FORECAST ERROR VALUE OF RICE HARVEST IN TANAH KAMPUNG DISTRICT

Error Value	$\alpha = 0.1$ $\beta = 0.1$	$\alpha = 0.1$ $\beta = 0.5$	$\alpha = 0.5$ $\beta = 0.1$	$\alpha = 0.5$ $\beta = 0.5$
ME	25288.68	25178.64	24978.21	24794.32
MAD	226580	2355.00	2298.11	2549.81
MAPE	0.17%	0.18%	0.17%	0.19%
MSE	6935856.07	7623425.19	8453445.91	10271647.02

Based on Table IV, the calculation results show that the smallest error value is: ME = 25288.68, MAD = 2265.80, MAPE = 17%, MSE = 6935856.07. This is used to predict the next year's harvest, namely:

TABLE V. FORECAST RESULTS OF RICE HARVEST IN TANAH KAMPUNG DISTRICT

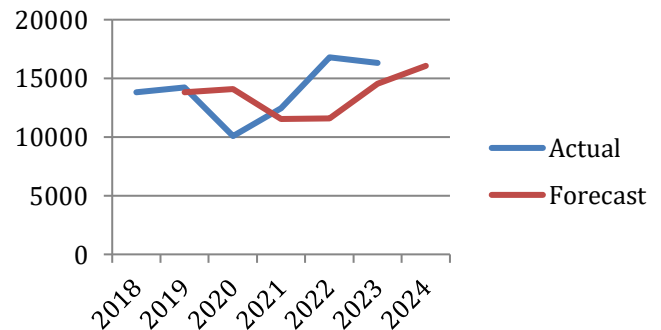| Year	Actual/ton	Forecast/ton
2018	13823	-
2019	14211	13823
2020	10082	14075
2021	12432	11537
2022	16790	11578
2023	16299	14559
2024		16065

Figure 4. Comparison of Actual and Estimated Paddy Rice Harvest

2) Forecast of Corn Harvest Results for Kumun Debai District

TABLE VI. RESULTS OF CALCULATION OF DOUBLE EXPONENTIAL SMOOTHING CORN HARVEST IN KUMUN DEBAI DISTRICT

Year	Actual/ton	Forecast/ton
2018	43	-
2019	47	43
2020	58	43
2021	44	45
2022	41	45
2023	49	44

TABLE VII. CALCULATION RESULTS OF CORN HARVEST FORECAST ERROR VALUE FOR KUMUN DEBAI DISTRICT

Error Value	$\alpha = 0.1$ $\beta = 0.1$	$\alpha = 0.1$ $\beta = 0.5$	$\alpha = 0.5$ $\beta = 0.1$	$\alpha = 0.5$ $\beta = 0.5$
ME	80.92	81.99	84.96	86.58
MAD	5.58	5.68	7.40	8.50

MAPE	0.11%	0.11%	0.15%	0.18%
MSE	52.69	52.86	65.32	84.85

Based on Table VII, the calculation results show that the smallest error value is: ME = 25288.68, MAD = 2265.80, MAPE = 17%, MSE = 6935856.07. This is used to predict the next year's harvest, namely:

TABLE VIII. FORECAST RESULTS OF CORN HARVEST IN KUMUN DEBAI DISTRICT

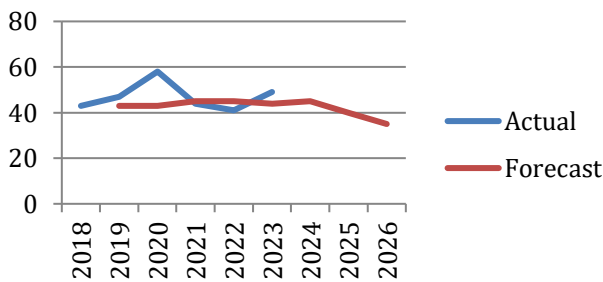| Year	Actual/ton	Forecast/ton
2018	43	-
2019	47	43
2020	58	43
2021	44	45
2022	41	45
2023	49	44
2024		45
2025		40
2026		35

Figure 5. Comparison of Actual and Forecast Corn Harvest

3) *Forecast of Sweet Potato Harvest Results for Pesisir Bukit District*

TABLE IX. RESULTS OF CALCULATION OF DOUBLE EXPONENTIAL SMOOTHING SWEET POTATOES, PESIR BUKIT DISTRICT

Year	Actual/ton	Forecast/ton
2018	0	-
2019	51	-
2020	129	28,05
2021	203	86,12
2022	136	158
2023	120	159,34

TABLE X. RESULTS OF CALCULATION OF THE ERROR VALUE OF THE FORECAST OF SWEET POTATO HARVEST IN PESIR BUKIT DISTRICT

Error Value	α = 0.1 β = 0.1	α = 0.1 β = 0.5	α = 0.5 β = 0.1	α = 0.5 β = 0.5
ME	39.09	55.32	137.85	172.40
MAD	103.31	89.65	66.03	79.99
MAPE	0.82%	0.71%	0.57%	0.70%
MSE	12898.23	10784.64	5696.84	6625.15

Based on Table From the calculation results, the smallest error value is obtained, namely: ME = 137.85, MAD = 66.03, MAPE = 0.57%, MSE = 5696.84, this is used to predict the next year's harvest, namely:

TABLE XI. FORECAST RESULTS OF SWEET POTATO HARVEST IN PESIR BUKIT DISTRICT

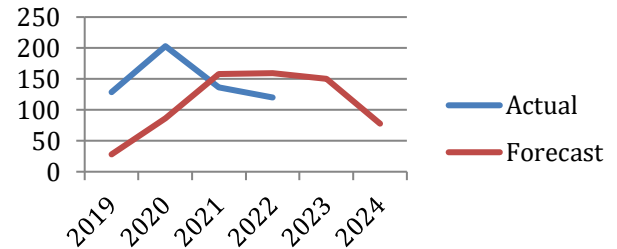| Year	Actual/ton	Forecast/ton
2018	0	-
2019	51	-
2020	129	28,05
2021	203	86,12
2022	136	158
2023	120	159,34
2024		150,05
2025		77,89

Figure 6. Comparison of Actual and Forecasts of Sweet Potato Harvest

So by using the value α = 0.1 and the value β = 0.1, it can be estimated that the yield of sweet potatoes in Pesisir Bukit District in 2018 was 150.05 tons and in 2019 it was 77.89 tons.

D. Screen Display

In the initial display, the admin can see a graph of land area based on sub-district. There are several menu bars, namely master data consisting of sub-district data, plant types, annual harvest results. In the analysis results menu there are forecast results for food crop harvests in each sub-district according to the double exponential smoothing calculation. The geographic information system menu will display harvest results based on the analysis results and you can see the distribution of plants in the geographic information system.
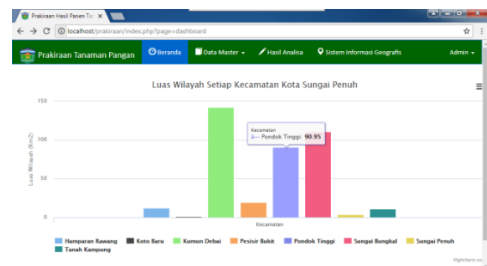

Figure 7. Harvest Forecast Results Graph
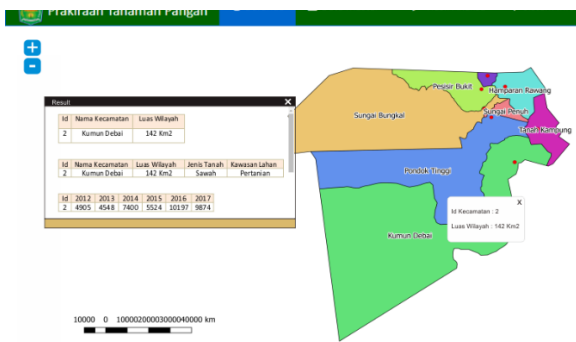

Figure 8. Forecast Results Menu Display

Figure 9. Geographic Information System Menu Display

IV. CONCLUSION

Based on the research results, it can be concluded that the double exponential smoothing method can be applied to predict food crop yields. This research was conducted in Sungai Banyak City to predict several types of food crops such as lowland rice, corn and sweet potato yields. In this research, to estimate corn harvest yields in Kumun Debai District using α and β values or the smallest error values, ME = 80.92, MAD = 5.58, MAPE = 11%, MSE = 52.69. So it is estimated that the corn harvest in Kumun Debai District in 2024 will be 45 tons, in 2025 it will be 40 tons and in 2026 it will be 35 tons. The Double Exponential Smoothing method has good performance in forecasting annual data. In previous research, forecasting had not been integrated with geographic information systems so that forecasting results were only in the form of tables and graphs. So this researcher integrated the forecasting results with a geographic information system to make it easier to see the prediction results displayed visually in the form of map polygons on the Geographic Information System and different legends for each sample or land.

REFERENCES

[1] Anggodo, Yusuf Ptiyo dan Wayan Firdaus Mahmudy. Peramalan Butuhan Hidup Minimum Menggunakan Automatic Clustering Dan Fuzzy Logical Relationship. *Jurnal Teknologi Informasi Dan Komputer* (JTIIK), 3(2), p.94-120.

[2] CC, Holt. 2004 Forecasting Seasonals And Trends By Exponentially Weighted Moving Averages. *Int. J. Forecast*. 20. P.5-13.

[3] Heizer, Jay dan Barry, Render. 2015. *Manajemen Operasi, Edisi 11,* Jakarta: Salemba Empat.

[4] Assauri, Sofjan. 2016. *Manajemen Operasi Produksi Edisi 3*. Jakarta : Raja Grafindo Persada.

[5] Stevenson, William J Dan Sum Chee Choung. 2014. *Operation Menagement: An Asian Prespective*. Jakarta : Salemba Empat.

[6] Budiyanto, E., 2016. *Sistem Informasi Geografis dengan Quatum GIS*. Yogyakarta : Andi Offset.

[7] Nyerges, T., 2009. *GIS and Society*, University of Washington, Seatle, WA, USA.

[8] Vatsavai, R., S. Shekhar, T. E. Burk, Lime, S., 2014. Mapserver : A high performance, interoperable, and open source web mapping and geo-spatial analysis system, *Geographic Information Science*, pp.400-4017.

[9] Chen Tian-En, L.P., Chen, Yunbin, G.Y., WANG.2009. Spasial Decision Support System For Percision Farming Based On GIS Web Service, *Information Technology And Application*. 2 p.372-376.

[10] Mohammed, E.S. Saleh, A.M., Belal, A.A. 2014. Sustainability Indicators For Agriculture Land Use Based GIS Spacial Modeling In Notrth On Sinai-Engypt, *The Engyptian Journal Of Remote Sensing And Space Science*. 17 p.1-15.

[11] E. Vercher, A. Corberan-Vallet, J.V. Segura, Et Al. 2012. Initial Conditions Estima-Tion For Improving Forecast Accuracy In Exponential Smoothing, 20. p. 517–533.

[12] R.R. Yager. 2013. Exponential smoothing with credibility weighted observations, *Inf.Sci.* 252. p. 96–105.

[13] A.L. Santiago Maia, F.D.A.T. De Carvalho, Et Al. 2011. Holt's Exponential Smoothingand Neural Network Models For Forecasting Interval-Valued Time Series, *Int. J.Forecast*. 27. p.740–759.

[14] A.B. Koehler, R.D. Snyder, J.K. Ord, Et Al. 2016, A Study Of Outliers In The Expo-Nential Smoothing Approach To Forecasting, *Int. J. Forecast*. 47(28). P.7–484.

[15] Nyerges, T., 2009. Gis And Society. University of washinton, staatle, WA,USA.

[16] B. Siregar and I. A. Butar-Butar and R. F. Rahmat and U. Andayani and F Fahmi, "Comparison of Exponential Smoothing Methods in Forecasting Palm Oil Real Production", Journal of Physics: Conference Series, IOP Publishing, 2017.

[17] Mumpuni, Retno. dkk. 2020. Design and Implementation of Inventory Forecasting System using Double Exponential Smoothing Method. Information Technology International Seminar (ITIS) IEEE 2020 p.119-124.

[18] F. Petropoulos, N. Kourentzes, K. Nikolopoulos, E. Siemsen, "Judgmental selection of forecasting models", Journal of Operations Management, Volume 69, 2018.

[19] R. Majid, S.Mir., "Advances in Statistical Forecasting Methods: An Overview", Economic Affairs, 63. 815-831, 2018.

[20] Y. Tikhamarine, D. S. Gamane, A. N. Ahmed, O. Kisi, A. El-Shafie, "Improving artificial intelligence models accuracy for monthly streamflow forecasting using grey Wolf optimization (GWO) algorithm", Journal of Hydrology, Volume 582, 2020.

[21] G. Kaur, A. Bala, I. Chana, "An intelligent regressive ensemble approach for predicting resource usage in cloud computing", Journal of Parallel and Distributed Computing, Elsevier, 2019.

[22] A. Vidianto, "Iii-73 Rancang Bangun Sistem Informasi Dan Peramalan Penjualan Menggunakan Analisa Forecasting." Accessed: Apr. 16, 2020.

[23] N. Aini, R. Ruktiari, M. R. Pratama, and A. F. Buana, "Sistem Prediksi Tingkat Pencemaran Polusi Udara dengan Algoritma Naïve Bayes di Kota Makassar Air Pollution Level Prediction System Using Naïve Bayes Algorithm in Makassar," Pros. Semin. Nas. Komun. dan Inform., vol. 3, pp. 83–90, 2019.

[24] Hasmin, erfan., Nurul Aini. 2020. Data Mining For Inventory Forecasting Using Double Exponential Smoothing Method. International Conference on Cybernetics and Intelligent System. IEEE 2020.

[25] Yicheng Li, Yang Liu, Wei Bai, Bin Li, Lixiong Xu. 2021. A Data-based Water-inflow Forecasting Method for Small/medium Sized Hydropower Plants in Spot Market. IEEE Sustainable Power and Energy Conference (iSPEC) 2021.