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Forecasting Agricultural Land in West Denpasar Using the Semi Averages Methods Applied in GIS

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***Abstract*— Agriculture is the main livelihood done in the days of ancestors in Indonesia. Agricultural land from 2014-2019 in West Denpasar Subdistrict experienced a significant decline because it was influenced by several things such as the conversion of agricultural land to settlements due to overcrowding or population movement from villages to cities. Another factor is that livelihoods as farmers do not promise to generate income as they wish so the community uses their land to build other businesses. Based on these problems, a study was conducted to predict land area from 2020-2025 using data on agricultural land area in the District of West Denpasar from 2014-2019. Forecasting methods used are semi-average trend statistical methods. The results of the forecasting will be implemented in a Geographic Information System (GIS) using ArcView software. This research can be used as a decision maker by the government to anticipate the area of agricultural land in accordance with forecasting results that experienced a decline from 2020-2025 to maintain the balance of natural ecosystems for the survival of the next generation of the nation.**

Keywords—Agriculture, Semi-average statistical method, forecasting, Geographic Information System (GIS)

I. INTRODUCTION

Agriculture is a livelihood that has been gradually developed in the ancestors of Indonesia and has become the main livelihood [15]. The area of agricultural land from year to year always decreases in the city of Denpasar-Bali, more precisely in the sub-district of West Denpasar. The decline in agricultural land is due to several factors, namely an increase in population so that agricultural land is used as a settlement, the community's assumption that being a farmer is not a main livelihood because their income is uncertain and cannot meet their daily needs so that many people move professions by opening shops / stalls on agricultural land and make agricultural land to open another business.

Based on this phenomenon, it means a lack of information to the public about the impact of converting agricultural land. The narrower agricultural land in the city of Denpasar will affect the balance of nature, the air will be more congested and global warming will occur. Based on these problems, it is necessary to analyze statistical forecasting using the semi-average trend analysis method which is implemented using Geographic Information Systems with ArcView 3.3 tools. Forecasting with this mapping is used to predict the area of agricultural land in the District of West Denpasar by using the previous data which is the data of 2014-2019 and predicting the next 6 years, namely 2020-2025 so that the government and society in general can think about the impact of land conversion and can think of solutions to tackle the conversion of the function of the agricultural land.

II. LITERATURE REVIEW

A. Forecasting Concept

Analysis of past data is very important because human behavior is influenced by previous conditions or times [16]. A company, a person or a particular institution in the decision-making based on data and previous conditions. Periodic series can be used to predict the state of things to come [9]. Periodic series have four components, namely trends, season variations, cycle variations, and irregular variations. Trend analysis methods used for forecasting consist of several ways, namely :

1. Semi-average method: The semi-average method creates trends by finding the average group of data.
2. Least Aquare Method: Trends with the least squares method are obtained by determining the trend line that has the smallest amount of the difference between the original data and the data on the trend line.
3. Quadratic Trend Method: For trends that are short and medium term, the trend is likely to follow a linear pattern. However, in the long run the pattern can change non-linearly. Therefore. if the pattern is not linear and is assumed to be a linear equation, the forecast results will be different or not suitable. One method that is not linear is the quadratic method
4. Exponential Trend Method: An exponential trend is a trend that has a rank or exponent of its time

B. GIS Concept

Geographic Information System (GIS) consists of three terms namely system, information and geography are a set of components or elements that are interconnected between the components / elements to achieve goals [12]. The concept of information is the result of data processing and geography is the study of the earth's surface. The concept of geographic information systems is a collection of components that interact with each other in data processing so as to produce geographic information which is implemented in the form of digital maps. Geographic information systems can also be defined as an information system that can analyze, store, update, integrate and display all forms of information relating to the surface of the earth [3]. The existence of an efficient Geographic Information

System (GIS) and capable of managing data with complex structures and with large numbers can help in the decision making process [14].

The definition of spatial data is data that has a georeference reference where various attribute data are located in various spatial units [9]. Spatial data is an important media for development planning and sustainable management of natural resources in continental, national and regional coverage [13]. The use of spatial data has increased after the digital mapping technology and its use in Geographic Information Systems. Spatial data formats can be vector (polygon, line, points) or raster. In this study using the vector format because the maps created are thematic maps. GIS is an information system that can combine graphic data (spatial) with text data (attributes) of objects connected geographically on earth (georeference) [1].

Non-spatial data or attribute data is a type of data that represents descriptive aspects of the phenomenon being modeled, this descriptive aspect includes items or properties of the phenomenon in question up to the time dimension [10].

Technologies such as Geographical Information Systems (GIS) have raised great expectations as potential means of coping with natural disasters[2].

C. Agricultural Land in Denpasar City

Since agriculture was first developed, the first concept is the fulfillment of human food needs [4]. Agriculture is a livelihood from ancient times but is still carried out in a search for fertile areas to maintain survival at that time [6]. Until now agriculture is a basic sector which is the foundation of other sectors, this causes agriculture to be integrated quite well into macroeconomic policy [7]. In the 1970s, Indonesia was quite successful in building a foundation for good economic growth after agricultural development was well integrated into macroeconomic policy [11]. The results of the success of agriculture can be seen clearly and felt directly by the entire community is food self-sufficiency that is able to meet food needs independently, around the 1980s [8].

Land use in the city of Denpasar consists of agricultural land, settlements, community forests, state forests, ponds and ponds and other uses. Agricultural land in the city of Denpasar consists of rice fields, fields and plantations. The proportion of land use in the city of Denpasar is 21.26% of land used for paddy land, 3.1% of land is used for upland land, 0.08% is used for plantation land, 61.29% of land is used for settlement, 0.59% as community forest, 4.21% of land is used as state forest, 0.59% as pond and pond land and other uses for 9.20%.

III. RESEARCH METHODS

A. Conceptual Model

The semi-average method makes trends by finding the average group of data. The steps in obtaining a trend line with this method are :

a. Group the data into two parts. If the amount of data is odd, the middle value can be eliminated or counted twice, namely 1 part being the first group and 1 part being the second group.
b. Calculate the average of the first group K1 and group K2. K1 is placed in the middle year in group 1 and K2 is placed in the middle year in group 2. The values of K1 and K2 are constants (a) and the location of the year is the base year. The values of K1 and K2 are intercepted in the trend equation.
c. Calculate the difference in K2-K1, if K2-K1> 0 means a positive trend and if K2 <K1, then the trend is negative.
d. The value of the trend change (b) is obtained by means of

$$b = \frac{K2-K1}{base\ year\ 2-base\ year\ 1}$$

e. To find out the magnitude of the next trend by entering the value (X) in the equation Y '= a + bX that already exists.

B. Systematic Research

This research, systematically done into the following stages :

1. Literature Study
   The first stage of this research is the study of literature, studying theories that support the forecasting technique, the concept of Geographic Information Systems, ArcView 3.3 Concept, studying the results of previous studies that are relevant to this research.
2. Observation of agricultural land in West Denpasar
   Conducting direct observations on the area of agricultural land in the district of West Denpasar.
3. Data collection
   This stage carries out the process of collecting data
4. Forecasting Calculation Process
   This stage analyzes the relevant forecasting methods used in this study. Forecasting method used in this study is a semi-average trend analysis (trend).
5. Spatial Data Analysis Process and Non Spatial Data
   At this stage, analysis of spatial data and non-spatial data is implemented, using ArcView 3.3
6. Layer Identification Process
   At this stage identify the layers that are used to store spatial data
7. Digitization Process
   At this stage the digitization process is carried out, namely conversion from manual to digital (computerized) so that it can produce digital maps

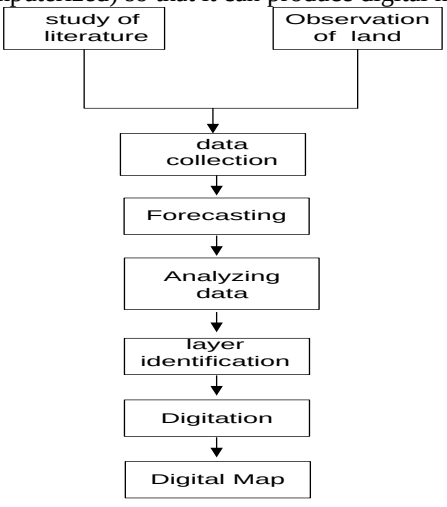

Fig.1. Research Flow

IV. Research Results and Discussion

1) *Spatial Data Denpasar Barat*

Denpasar Barat sub-district is one of the districts in Denpasar City which is located in the west with an area of 24.06 km2[5]. This sub-district has a capital city located in Padang Sambian Village. Based on geographical location, the boundaries of Denpasar Barat are as follows:

North : North Denpasar sub-district and Mengwi sub-district
West : Kuta Utara sub-district
South : Kuta sub-district and South Denpasar sub district
East : East Denpasar sub-district and North Denpasar sub-district

Based on geological and environmental aspects, this area is quite safe from the danger of relatively small erosion because the area is relatively flat. However, because the area has a basin, especially in Kelod Pemecutan Area, the drainage flow accumulates in the area, so that it always experiences inundation when it rains. The type of land area consists of yellowish brown latosol whose distribution occupies almost the entire area.

Demographically, West Denpasar Sub-district consists of 3 kelurahan, namely Padang Sambian Kelurahan, Pemecutan Kelurahan and Dauh Puri Kelurahan and 8 Villages consisting of Klod Pemecutan Village, Padang Sambian Village Kaja, Padang Sambian Klod Village, Dauh Puri Kangin Village, Dauh Puri Klod Village, Dauh Puri Kauh Village, Tegal Kerta Village, and Tegal Harum Village. The following is an area table for each village in the West Denpasar sub-district as follows:

Fig.2. Map of West Denpasar

2) *Non Spatial Data Denpasar Barat*

The area of agricultural land observed from 2014-2019 in the district of West Denpasar with the aim to see the comparison of the amount of agricultural land in the next 6 years in accordance with forecasting. This data is sourced from the Department of Agriculture, food crops and horticulture, Denpasar City.

TABLE I
TOTAL AREA OF VILLAGE/KELURAHAN IN WEST DENPASAR

No	Years	agricultural land area (km^2)
1	2014	1.353
2	2015	1.867
3	2016	1.636
4	2017	1.405
5	2018	1.174
6	2019	0.943

3) *Forecasting Agricultural Land Area (2020-2025)*

Forecasting calculations used in this study are using the semi-average trend analysis forecasting method. The data predicted is the area of agricultural land in 2015 to 2019 in accordance with statistical data obtained from the Denpasar city agriculture department. Analysis of agricultural broad forecasting was carried out in the district of West Denpasar.

TABLE II.
BROAD OF AGRICULTURE IN WEST DENPASAR

No.	Village /Kelurahan	Total Area (km^2)
1.	Kelurahan Padang Sambian	3.70
2.	Kelurahan Pemecutan	1.85
3.	Kelurahan Dauh Puri	0.60
4.	Desa Pemecutan Kelod	4.41
5.	Desa Padang Sambian Kaja	4.06
6.	Desa Padang Sambian Klod	4.11
7.	Desa Dauh Puri Kangin	0.58
8.	Desa Dauh Puri Kauh	1.90
9.	Desa Dauh Puri Klod	1.88
10.	Desa Tegal Kerta	0.35
11.	Desa Tegal Harum	0.62
Total Area of West Denpasar Sub-district		24.06

TABLE III
CALCULATION OF AGRICULTURAL FORECASTING OF WEST DENPASAR IN 2020-2025

Group	Years	agricultural land area	Total	Average	X value for the base year 2016	X value for the base year 2019
I	2014	1.353	4856	1618	-2	-5
	2015	1.867			-1	-4
	2016	1.636			0	-3
II	2017	1.405	3522	1174	1	-2
	2018	1.174			2	-1
	2019	0.943			3	0
	Year of forecasting					
	2020				4	1
	2021				5	2
	2022				6	3
	2023				7	4

	2024				8	5
	2025				9	6

In accordance with the data in the table it can be concluded that the data tends to decrease, this means a trend / downward trend (negative). The formula for negative trends is

Y' = a-bX

The steps are

1. Calculate the average for each 1. Divide data into 2 groups. The amount of data to be processed is 6 (2014-2019), the six data are grouped into 2 namely group I (2014-2016) and group II (2017-2019).Calculate the average of each group

   K1 = (1.353+ 1.867+1.636)/3 = 1.618
   K2 = (1.405+1.174+0.943)/3 = 1.174

2. Calculating the value of change for a negative trend

$$b = \frac{K1-K2}{base\ year\ 2-base\ year\ 1}$$

$$= \frac{1.618-1.174}{2019-2016}$$

$$= \frac{0.445}{3}$$

= 0.148

3. The trend equation is
   a. The trend equation for the 2016 base year is Y ' = 1.618 – 0.148X
   b. The trend equation for base year 2019 is Y ' = 1.174 – 0.148X
5. Calculate forecasting for 2020, 2021, 2022, 2023.2024 and 2025 are as follows:

Forecasting 2020 uses the base year 2016
(X = 4)
Y' = 1.618 – 0.148X
= 1.618 – 0.148*4
= 1.618 – 0.592
= 1.026

Forecasting 2020 uses the base year 2019
(X = 1)
Y' = 1.174 – 0.148X
= 1.174 – 0.148 *1
= 1.174 – 0.148
= 1.026

Forecasting in 2021 uses the base year 2016
(X = 5)
Y' = 1.618 – 0.148X
= 1.618 – 0.148*5
= 1.618 – 0.74
= 0.878

Forecasting in 2021 uses the base year 2019
(X = 2)
Y' = 1.174 – 0.148X
= 1.174 – 0.148*2
= 1.174 – 0.296
= 0.878

Forecasting in 2022 uses the 2016 base year
(X = 6)
Y' = 1.618 – 0.148X
= 1.618 – 0.148*6
= 1.618 – 0.888
= 0.73

Forecasting in 2022 uses a base year 2019
(X = 3)
Y' = 1.174 – 0.148X
= 1.174 – 0.148*3
= 1.174 – 0.444
= 0.73

Forecasting in 2023 uses a base year 2016
(X = 7)
Y' = 1.618 – 0.148X
= 1.618 – 0.148*7
= 1.618 – 1.036
= 0.582

Forecasting in 2023 uses a base year 2019
(X = 4)
Y' = 1.174 – 0.148X
= 1.174 – 0.148*4
= 1.174 – 0.592
= 0.58

Forecasting in 2024 uses a base year 2016
(X = 8)
Y' = 1.618 – 0.148X
= 1.618 – 0.148*8
= 1.618 – 1.184
= 0.434

Forecasting in 2024 uses a base year 2019
(X = 5)
Y' = 1.174 – 0.148X
= 1.174 – 0.148*5
= 1.174 – 0.74
= 0.434

Forecasting in 2025 uses a base year 2016
(X = 9)
Y' = 1.618 – 0.148X
= 1.618 – 0.148*9
= 1.618 – 1.332
= 0.286

Forecasting in 2025 uses a base year 2019
(X = 6)
Y' = 1.174 – 0.148X
= 1.174 – 0.148*6
= 1.174 – 0.888
= 0.286

In table IV is the result of the calculation of the forecast area of agricultural land in the District of West Denpasar District from 2020-2025. Based on table IV it can be seen that the area of agricultural land has decreased from 1,026 km2 in 2020 decreasing to 285 km2 in 2025.

TABLE IV.
BROAD AGRICULTURE OF FORECASTING RESULTS FOR 2020-2025

No	Tahun	Luas Hasil Peramalan (km^2) Tahun 2020-2025

1	2020	1.026
2	2021	878
3	2022	729
4	2023	581
5	2024	433
6	2025	285

Table V is a comparison table between the area of agricultural land in the District of West Denpasar from 2014-2019 with the area of agricultural land resulting from forecasting calculations from 2020-2025. Based on the table as a whole from year to year the area of agricultural land has decreased from 1,353 km^2 from 2014 decreased to 285 km2 from the forecast forecast in 2025.

TABLE V
COMPARISON OF AGRICULTURE OF AGRICULTURE IN 2014-2019 WITH FORECASTING RESULTS FOR 2020-2025

No	Years	Agricultural land area (km^2) (2014-2019)	Forecasting Year	Forecasting Results Area (km^2) (2020-2025)
1	2014	1.353	2020	1.026
2	2015	1.867	2021	0.878
3	2016	1.636	2022	0.73
4	2017	1.405	2023	0.582
5	2018	1.174	2024	0.434
6	2019	0.943	2025	0.286

4) Implementation of Forecasting Results to GIS

Then digitizing the West Denpasar District to GIS using the Arcview software can be seen in Fig.2. The digital map formed consists of 3 layers, namely the village / kelurahan layer in West Denpasar District, the number of agricultural land layers in 2014-2019 and layer to store the results of agricultural land forecasting in the District of West Denpasar in 2020-2025

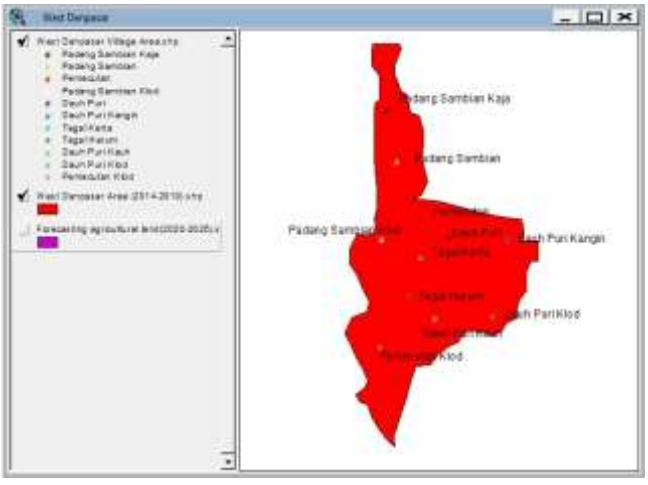

Fig.3. Digitizing Map of West Denpasar

In Fig.3 is the layer to store data on agricultural land in the District of West Denpasar in 2014-2019. Spatial data and non-spatial data are integrated so that we can find information interactively.

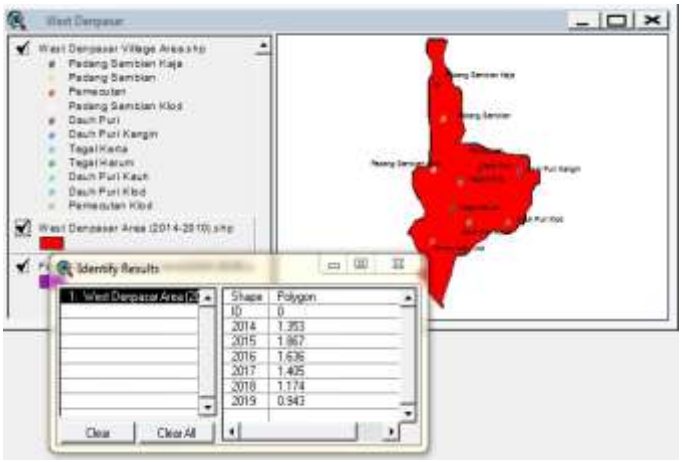

Fig.4. Implementation of 2014-2019 Agricultural Land to GIS

In Fig.4 is the layer to store forecasting data in the District of West Denpasar in 2020-2025. Spatial data and non-spatial data can also be integrated. Spatial Data is the location of the village / kelurahan and the digitization map of West Denpasar Sub-district while the non-spatial data is forecast data stored in a table.

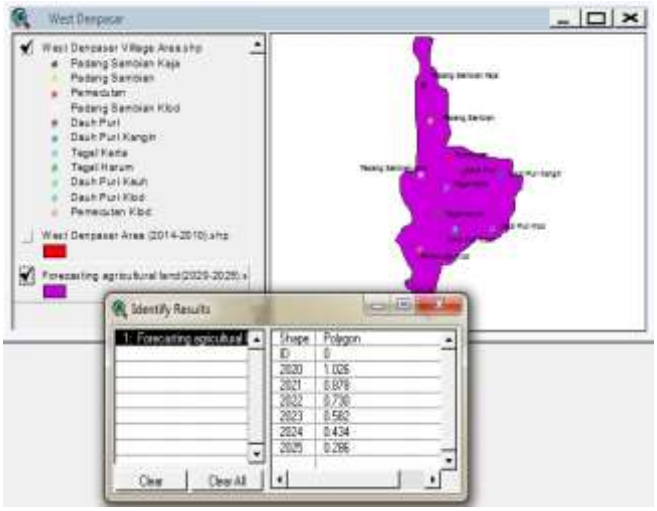

Fig.5. Implementation of 2020-2025 Forecasting Results to GIS

Fig.5 is a graph formed with quantitative data on the number of agricultural land in km^2 units. On the graph, it is seen that overall agricultural land from 2014-2019 experienced a decline, only in 2015 it increased from 2014 due to the use of vacant land to be used as agricultural land, but after 2015 there was a decrease again due to the conversion of agricultural land to residential areas. as urbanization grows, people move from villages to cities.

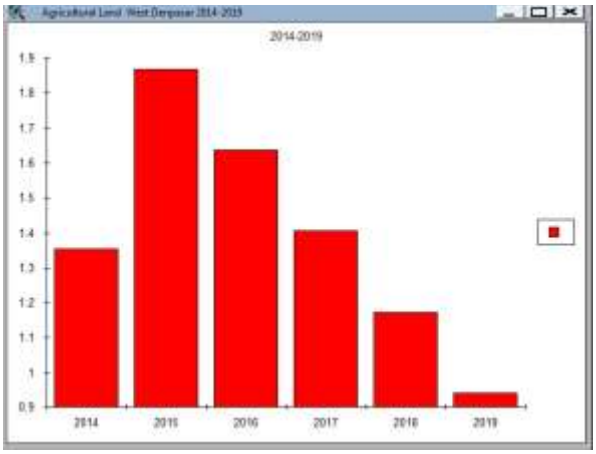

Fig.6. Chart of Agricultural Land 2014-2019

Land Estimation Results Graph In Fig.6 is a graph of agricultural land forecast results in the District of West Denpasar from 2014-2019. Based on the graph, it can be seen the decline in agricultural land in the District of West Denpasar. This is a concern of the government not to happen if Agriculture 2020-2025 is carried out the conversion of agricultural land to residential areas or used for other businesses.

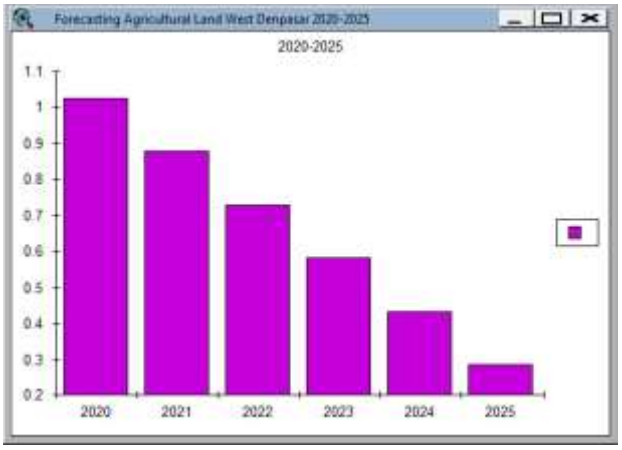

Fig.7. Charts of Agricultural Land Forecasting Results 2020-2025

V. CONCLUSION

Based on the description of forecasting agricultural products in the District of West Denpasar using GIS it can be concluded

1. GIS is able to implement forecasting results by integrating spatial data and non-spatial data so as to produce an interactive system
2. Results Forecasting of agricultural land in the District of West Denpasar from 2020-2025 has decreased significantly so that the government is concerned in anticipating the conversion of agricultural land to settlements or other businesses for the balance of the natural ecosystem.

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