Climate forecasting uses backpropagation algorithm artificial neural network model for agricultural planning in Gowa regency

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Abstract. Climate is defined as the average size and variability of the relevant quantities of certain variables over a period of time with a period of time from monthly to annual or millions of years. This study aims to develop climate prediction models that are used for planning agricultural cultivation activities. The method used in predicting climate is Backpropagation Artificial Neural Network technique based on rainfall data in 1975-2018 in Pallangga sub-district, 1992-2018 in Bontomarannu sub-district and 1997-2018 in Bontonompo sub-district. The results showed that the climate classification according to Oldeman in Bontomarannu sub-district was in the B3 climate type suitable for planting rice crops twice and crops once a year while Pallangga sub-districts and Bontonompo sub-districts were in C3 climate type suitable for planting one-time rice crops and crops twice in one year.

1. Introduction
Climate change represents one of the greatest environmental threats facing planet Earth today and it has become one of the most pressing scientific challenges facing society [1,2].

Farmers make decisions on a daily basis that affect their financial returns and overall welfare. The consequences of decisions are often not known with certainty until long after the decisions occur and the outcomes can be better or worse than expected. Often the decisions are made based on some type of forecast, such as weather, or climate. Weather is the atmosphere changing from day-to-day: a rainstorm or cold snap. Weather-based decisions are generally operational by nature and involve activities that should happen in the very near future, most of the time in less than a week. Examples are irrigation, fertilizing, and harvesting. Climate-based decisions are normally pre-season decisions and tend to be more strategic in nature. Examples of climate-based decisions can be the choice of variety planted, acreage allocation, pre-season purchase of inputs, and marketing.

Predictions of future events, like climate changes, are rarely made with certainty and can, at best, be described in probabilistic terms. New observations and improved models will lead to updated predictions, where the original estimates are revised, upwards or downwards, as the case may be. Revised forecasts such as these could give rise to different expectations for future developments. The task of predicting a forecaster’s future predictions, which is the theme of the present studies, could be a challenge [3].

There are plenty of technologies available to data mining practitioners, including Artificial Neural Networks, Regression, and Decision Trees. Neural network is a parallel processing network which...
made with simulating the intuitive thinking of human, the neural network in data mining was not optimistic, and the key reasons are that the nerve organs network has the problems of complex structure, poor interpretability and long training time [4].

Artificial neural network (ANN) is one of the methods that is suitable to deal with the internal relations of complex model because of its highly nonlinear, large amounts of data parallel processing, high robustness, and fault tolerance [5].

A backpropagation neural network is a neural network architecture that serves as a tool to solve various problems, including a reasonably good method of making predictions (forecasting) [6]. It is expected that with the use of this method the results will be as desired, because the backpropagation algorithm allows to avoid difficulties by using learning rules that are similar to the plasticity of time spikes that depend on synapses [7].

In Environmental area, neural network can be used to solve available problems and issues of processes modelling of real world by designing composed architecture with meta-heuristic algorithms. These problems include nonlinear multidimensional space and chaos theory. It removed the practical problems of designing neural networks for high efficiency and indicated that combined networks can guarantee it [8].

The purpose of this study is to conduct a learning / training process on the backpropagation algorithm, so that it will produce accurate and practical predictions, especially on the model used for planning agricultural training in Gowa Regency. The author hopes that this research will be useful for other researchers who are conducting research in the field of artificial neural specials that discuss weather models and are beneficial for the government in making cropping patterns.

2. Method

2.1. Analyses
Analyses is defined as solving or separating a communication (event, understanding) into its constituent elements, so that the idea (understanding, concept) is relatively clearer and / or the relationship between ideas is more explicit [7].

2.2. Forecasting
Forecasting is a process to estimate events / things in the future. Forecasting requires historical data and projects it into the future with some mathematical models. Transformer peak load forecasting can be categorized as quantitative forecasting. This quantitative forecasting can be applied if the following 3 conditions are met: 1. There is information about the past. 2. Such information can be quantified in the form of numerical data. 3. It can be assumed that some aspects of past patterns will continue in the future [9].

2.3. Learning in ANN
There are three major learning paradigms; supervised learning, unsupervised learning and reinforcement learning. Usually they can be employed by any given type of artificial neural network architecture. Each learning paradigm has many training algorithms.

Supervised learning is a machine learning technique that sets parameters of an artificial neural network from training data. The task of the learning artificial neural network is to set the value of its parameters for any valid input value after having seen output value. The training data consist of pairs of input and desired output values that are traditionally represented in data vectors.

In order to solve a given problem of supervised learning various steps has to be considered. In the first step we have to determine the type of training examples. In the second step we need to gather a training data set that satisfactory describe a given problem. In the third step we need to describe gathered training data set in form understandable to a chosen artificial neural network. In the fourth step we do the learning and after the learning we can test the performance of learned artificial neural
network with the test (validation) data set. Test data set consist of data that has not been introduced to artificial neural network while learning [10].

Pattern association is usually supervised learning. ANNs compete well with statistical methods in pattern recognition, especially when the systems contain high level of noise and variation [11].

The results of the application may also include qualitative recommendations regarding possible adaptation, or agronomic management strategies to take advantage of the current climate forecast [12].

2.4. Research Framework

The research framework used in solving this research problem.

![Figure 1. The research framework.](image)

Based on the framework in figure 1, each step can be described as follows: 1. Collecting Data. At this stage, rainfall data from 1975 to 2018 were obtained from the Public Works Department; 2. Literature study is the first step in this research, this literature study is carried out to add to the basic knowledge and theory used in this research; 3. Identification of problems at the stage of identifying this problem, it is done after all data has been fulfilled and then the appropriate dataset is obtained to be carried out at the conversion stage of the data obtained in accordance with the specified weights; 4. Preprocessing. The steps taken are identifying or changing data that makes data more consistent, and eliminates excessive data; 5. Determine the model. The results of this stage are several models of artificial neural networks with the Backpropagation algorithm to determine the pattern; 6. Testing data. Processing results after the model determination process is complete, the testing phase is carried out on the results of data processing using Matlab R2017b Software; 7. Prediction is made to know the rainfall in the future with the Artificial Neural Network model with the most accurate Backpropagation method (figure 2); 8. Final evaluation; 9. Final evaluation is carried out to find out whether the test data processing results are as expected, namely by calculating the correlation, regression, MSE and MAE values.
Figure 2. Prediction Using the Backpropagation Neural Network Method.
3. Result and Discussion

3.1. Analysis

The first thing to do to backpropagation programs with Matlab software is to initialize the network. Determine the desired parameter value before doing the Training in order to obtain optimal results. After the parameters have been determined, then form the data table in such a way as to be easy in processing and does not occur inconsistent data and avoid redundant data.

3.2. Result

Table 1. MSE value from 3 sub-districs in gowa regency.

| Year | Jan | Feb | March | April | May | June | July | Aug | Sep | Oct | Nov | Dec | Status | \( r \) | \( R^2 \) | MSE | MAE |
|------|-----|-----|-------|-------|-----|------|------|-----|-----|-----|-----|-----|-------|------|------|-----|-----|
| 2019 |    |    |       |       |     |      |      |     |     |     |     |     |       |      |      |     |     |
| Pallangga | 925 | 385 | 395 | 138 | 136 | 102 | 92 | 20 | 18 | 56 | 512 | 587 | C3 | 0.99945 | 99.945 | 0.00080046 | 0.0187 |
| Tipe  | WM | WM | WM | HM | HM | HM | DM | DM | DM | DM | WM | WM | WM | WM | WM | WM | WM |
| CPP | P | P | P | SC | SC | SC | SC | SC | SC | SC | SC | SC | P | P | P | P | P |
| Bontomaranu | 2029 | 2054 | 1972 | 728 | 230 | 15 | 30 | 9 | 31 | 141 | 612 | 3027 | B3 | 0.9995 | 99.95 | 0.00091726 | 0.0205 |
| Tipe  | WM | WM | WM | HM | HM | DM | DM | DM | DM | HM | WM | WM | WM | WM | WM | WM | WM |
| CPP | P | P | P | P | SC | SC | SC | SC | SC | SC | SC | P | P | P | P | P | P |
| Bontonomo | 493 | 560 | 630 | 73 | 96 | 40 | 66 | 20 | 0 | 19 | 261 | 864 | C3 | 0.99953 | 99.953 | 0.00092963 | 0.0179 |
| Tipe  | WM | WM | WM | DM | DM | DM | DM | DM | DM | DM | DM | WM | WM | WM | WM | WM | WM |
| CPP | P | P | P | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC |
| 2020 |    |    |       |       |     |      |      |     |     |     |     |     |     |       |      |      |     |     |
| Pallangga | 938 | 381 | 391 | 134 | 129 | 100 | 82 | 20 | 28 | 75 | 509 | 583 | C3 | 0.99946 | 99.946 | 0.00080046 | 0.0216 |
| Tipe  | WM | WM | WM | HM | HM | HM | DM | DM | DM | DM | DM | DM | WM | WM | WM | WM | WM |
| CPP | P | P | P | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC |
| Bontomaranu | 2008 | 2065 | 1951 | 803 | 281 | 27 | 11 | 2 | 5 | 99 | 391 | 3019 | B3 | 0.99951 | 99.951 | 0.00091728 | 0.0219 |
| Tipe  | WM | WM | WM | WM | WM | WM | DM | DM | DM | DM | DM | DM | WM | WM | WM | WM | WM |
| CPP | P | P | P | P | P | SC | SC | SC | SC | SC | SC | SC | P | P | P | P | P |
| Bontonomo | 498 | 561 | 620 | 66 | 70 | 48 | 62 | 18 | 2 | 25 | 264 | 854 | C3 | 0.99957 | 99.957 | 0.0009975 | 0.0211 |
| Tipe  | WM | WM | WM | DM | DM | DM | DM | DM | DM | DM | DM | DM | WM | WM | WM | WM | WM |
| CPP | P | P | P | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC |
| 2021 |    |    |       |       |     |      |      |     |     |     |     |     |     |       |      |      |     |     |
| Pallangga | 938 | 380 | 387 | 132 | 115 | 90 | 71 | 31 | 45 | 84 | 511 | 582 | C3 | 0.99947 | 99.947 | 0.00082242 | 0.024 |
| Tipe  | WM | WM | WM | HM | HM | HM | DM | DM | DM | DM | DM | DM | WM | WM | WM | WM | WM |
| CPP | P | P | P | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC |
| Bontomaranu | 2062 | 2097 | 1882 | 817 | 263 | 58 | 13 | 0 | 6 | 97 | 567 | 3026 | B3 | 0.99951 | 99.951 | 0.00092512 | 0.0238 |
| Tipe  | WM | WM | WM | WM | WM | WM | WM | DM | DM | DM | DM | DM | WM | WM | WM | WM | WM |
| CPP | P | P | P | P | P | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC |
| Bontonomo | 500 | 558 | 632 | 58 | 54 | 50 | 69 | 20 | 0 | 22 | 280 | 843 | C3 | 0.99957 | 99.957 | 0.0009975 | 0.0231 |
| Tipe  | WM | WM | WM | DM | DM | DM | DM | DM | DM | DM | DM | DM | WM | WM | WM | WM | WM |
| CPP | P | P | P | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC |
| 2022 |    |    |       |       |     |      |      |     |     |     |     |     |     |       |      |      |     |     |
| Pallangga | 950 | 369 | 393 | 127 | 112 | 96 | 76 | 16 | 39 | 94 | 518 | 576 | C3 | 0.99949 | 99.949 | 0.00086571 | 0.0227 |
| Tipe  | WM | WM | WM | HM | HM | HM | DM | DM | DM | DM | DM | DM | WM | WM | WM | WM | WM |
| CPP | P | P | P | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC | SC |

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CPP | P | P | P | SC | SC | SC | SC | SC | SC | SC | SC | P 
---|---|---|---|---|---|---|---|---|---|---|---|---
Bontomarannu | 2030 | 2126 | 1847 | 880 | 297 | 6 | 0 | 15 | 0 | 74 | 592 | 3027 | B3 | 0.99952 | 99.952 | 0.00092512 | 0.027 
Tipe | WM | WM | WM | WM | DM | DM | DM | DM | DM | WM | WM | P 
CPP | P | P | P | P | P | P | P | SC | SC | SC | SC | P 
Bontonompo | 502 | 554 | 656 | 51 | 42 | 56 | 69 | 25 | 8 | 18 | 283 | 837 | C3 | 0.99957 | 99.957 | 0.00099906 | 0.0217 
Tipe | WM | WM | WM | DM | DM | DM | DM | DM | DM | WM | WM | P 
CPP | P | P | P | SC | SC | SC | SC | SC | SC | SC | SC | P 

2023

Pallangga | 977 | 362 | 389 | 136 | 108 | 95 | 67 | 6 | 41 | 107 | 513 | 571 | C3 | 0.9995 | 99.95 | 0.00091577 | 0.0243 
Tipe | WM | WM | WM | HM | HM | DM | DM | DM | DM | HM | WM | WM 
CPP | P | P | P | SC | SC | SC | SC | SC | SC | SC | SC | P 
Bontomarannu | 2009 | 2182 | 1801 | 931 | 313 | 0 | 0 | 26 | 3 | 61 | 620 | 3001 | B3 | 0.99953 | 99.953 | 0.00092963 | 0.0241 
Tipe | WM | WM | WM | WM | WM | DM | DM | DM | DM | DM | WM | WM 
CPP | P | P | P | P | P | P | P | SC | SC | SC | SC | P 
Bontonompo | 494 | 544 | 669 | 63 | 44 | 57 | 66 | 23 | 5 | 16 | 267 | 849 | C3 | 0.99958 | 99.958 | 0.00099989 | 0.0211 
Tipe | WM | WM | WM | DM | DM | DM | DM | DM | DM | WM | WM | P 
CPP | P | P | P | SC | SC | SC | SC | SC | SC | SC | SC | P 

Where WM is wet month, HM is humid month, DM is dry month, CPP is Cropping Planning Pattern, P is Paddy and SC is Secondary Crops.

The above table explains that the smallest MSE value is in the prediction of 2019 in Pallangga sub-district, which is 0.00080046. While the smallest MAE value is found in predictions for 2019 in the Bontonompo sub-district, which is 0.0179. Based on this, the results of this prediction can be used to recommend cropping patterns in three districts in Gowa Regency.

Based on the classification of wet and dry moon according to Oldeman classification. The climate types in the three districts are in the range of B3 and C3. The B3 climate type is suitable for rice plants twice and crops once a year while the C3 climate type is suitable for rice plants and crops twice a year. The second planting of secondary crops must be done with careful calculation not to fall in the dry month.

Irrigation anticipation is carried out by increasing irrigation water supply for the dry season. The decrease in rainfall in the dry season is feared by the reduced supply of irrigation. What was done to anticipate the drought was, among others, by supplying pumps and using water bags as economically as possible. Furthermore, there needs to be further analysis of the areas in the three districts which are vulnerable to being affected by drought.
4. Conclusion

Based on the description of the results of the previous discussion, it can be concluded that:

1. Rainfall prediction results for 2019-2023 in three sub-districts namely Pallangga, Bontomarannu and Bontonompo Sub-districts indicate that the type of rainy month will fluctuate from wet, humid to dry months.

2. The results of the analysis of monthly rainfall accumulation from 2019 to 2020 include the Oldeman B3 and C3 climate types.

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