International Journal Of Information System & Technology
Vol. 2, No. 1, (2018), pp. 26-34

Implementation of Backpropagation Artificial Neural Networks to Predict Palm Oil Price Fresh Fruit Bunches

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Abstract

Riau Province is one of the regions known for its plantation products, especially in the oil palm sector, so that Riau Province and regional districts focus on oil palm plants as the main commodity of plantations in Riau. Based on data from the Central Bureau of Statistics (BPS) of Riau Province, the annual production of oil palm plantations, especially smallholder plantations in Riau province has always increased. So is the demand for world CPO. But sometimes the selling price of oil palm fresh fruit bunches (FFB) for smallholder plantations always changes due to many influential factors. With the Artificial Neural Network approach, the Backpropagation algorithm we conduct training and testing of the time series variables that affect the data, namely data on the area of oil palm plantations in Riau Province; Total palm oil production in Riau Province; Palm Oil Productivity in Riau Province; Palm Oil Exports in Riau Province and Average World CPO Prices. Then price predictions will be made in the future. Based on the results of the training and testing, the best Artificial Neural Network (ANN) architecture model was obtained with 9 input layers, 5 hidden layers and 1 output layer. The output of RMSE 0000699 error value and accuracy percentage is 99.97% so that it can make price predictions according to the given target value.

Keywords: *Artificial Neural Network, Backpropagation, Palm Oil, Prediction.*

1. Introduction

Riau Province is one of the regions known for its plantation products, especially in the oil palm sector, so that Riau Province and regional districts focus on oil palm plants as the main commodity of plantations in Riau, based on the first consideration that the land and climate conditions in Riau Province are suitable for oil palm plantations, the second in terms of marketing, Riau Province has ports as marketing transportation access and is adjacent to Malaysia and Singapore as marketing targets. Based on data from BPS Production of plantation products, especially smallholder plantations in Riau province every year has always been increasing, so has world CPO demand, But sometimes the selling price of oil palm FFB for smallholder plantations is always changing, so this needs to be analyzed in the coming year[1]–[3]. Artificial Neural Network[4]–[8] backpropagation is an algorithm for the development of Artificial Neural Networks using backpropagation[9]–[11], we can use multiple screens to train the network to get a balance in pattern recognition. From the description above, this study will try to study and analyze data testing to predict the price of oil palm FFB in the coming year.

2. Rudimentary

2.1. Artificial Neural Network

Artificial Intelligence is a study of how to make computers do things that can now be done better by humans by using forms of symbols rather than numbers organized and

ISSN : 2580-7250

analyzed so that they can be understood and applied in decision making and problem solving[1], [12]

2.2. Backpropogation

Backpropagation is one part of the Neural Network using the supervised learning model that can minimize errors in the output generated by the network because it uses a multilayer concept[13].

3. Research Methodology

In the case of this study, the method used is a descriptive approach or survey that is collecting as much data as possible about the factors related to variable data that affect the price of oil palm FFB, then analyzing these factors and items to find their role in predictions affect the price of Oil Palm FFB in Riau Province.

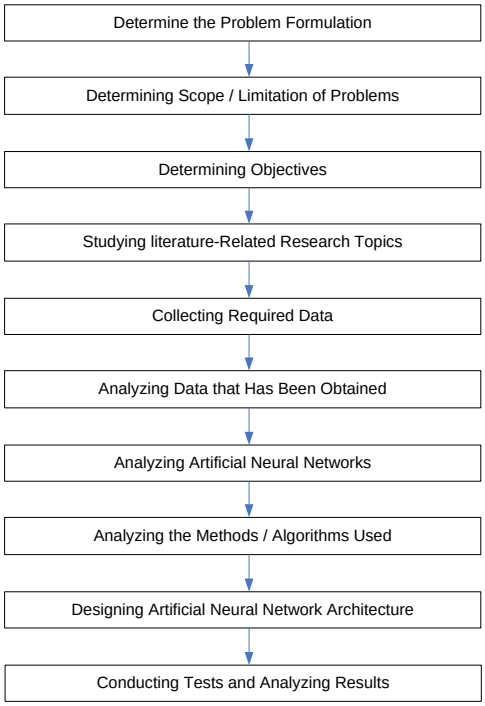


Figure 1. Research Methodology

4. Result and Discussion

4.1. Analysis

In analyzing data from the field that affects the price of oil palm FFB in Riau province includes five things: Area of Oil Palm Plantation, Palm Oil Production, Riau Palm Oil Productivity, Palm Oil Export, and World CPO Prices. Based on data obtained from the Central Statistics Agency and the Agriculture and Plantation Service of Riau Province from 2008 to 2017 and can be seen in Table 1 as follows:

Table 1. Factors That Affect the Price of FFB

Year	Area of Riau Palm Oil Plantation (Unit : Ha)			Riau Palm Oil Production Amount (Unit : Ton)			Riau Palm Oil Productivity (Unit : Kg/Ha)		
	People's Plantation	State Plantation	Private Plantation	People's Plantation	State Plantation	Private Plantation	People's Plantation	State Plantation	Private Plantation
F1	*F2*	*F3*	*F4*	*F5*	*F6*	*F7*	*F8*	*F9*	*F10*
X1	845,232	74,721	562,402	2,368,076	239,277	2,205,532	3,775.41	3,898.92	4,362.82
X2	889,916	75,395	646,846	2,658,044	274,637	2,378,687	3,805.33	4,339.34	4,344.00
X3	1,055,543	75,841	648,670	2,894,459	215,056	2,386,453	3,852.49	3,790.00	4,352.34

Year	Area of Riau Palm Oil Plantation (Unit : Ha)			Riau Palm Oil Production Amount (Unit : Ton)			Riau Palm Oil Productivity (Unit : Kg/Ha)		
	People's Plantation	State Plantation	Private Plantation	People's Plantation	State Plantation	Private Plantation	People's Plantation	State Plantation	Private Plantation
X4	1,205,498	78,979	634,551	3,174,176	244,393	2,330,298	3,595.30	3,826.83	4,134.52
X5	1,297,294	77,740	764,154	3,485,172	225,124	2,674,241	3,644.78	3,775.54	4,052.60
X6	1,348,076	83,670	761,975	3,692,195	249,321	2,705,481	3,413.61	4,014.64	4,024.34
X7	1,357,819	85,586	847,331	3,706,891	264,791	3,021,559	3,373.00	3,943.00	4,048.00
X8	1,354,503	91,854	954,519	3,611,853	312,012	4,135,981	3,228.00	3,878.00	4,974.00
X9	1,360,855	92,130	977,523	3,651,687	322,970	4,531,989	3,235.00	3,890.00	4,996.00
X10	1,386,575	92,714	1,013,887	3,677,989	328,159	4,715,000	3,251.00	3,928.00	5,105.00

Export of Riau Palm Oil (Unit : Ton)				World CPO Prices (Unit : $ / mt)
CPO HC : 1511 10000	OPO HC : 1511 90000	COPK HC : 1513 21000	OCOPK HC : 1513 29000	The Pink Sheet, World Bank
F11	***F12***	***F13***	***F14***	***F15***
3,786,818	3,196,042	526,585	50,818	949
3,914,362	4,068,195	660,208	69,487	683
3,829,333	3,486,760	541,829	92,924	901
3,338,428	4,180,607	503,057	147,687	1,125
2,783,650	5,346,979	198,606	359,393	999
2,566,013	5,525,954	74,433	532,193	857
2,115,609	6,595,051	94,327	562,397	821
3,249,072	7,512,725	260,789	607,532	623
2,821,102	7,014,056	129,062	563,959	700
3,035,087	7,263,390	194,925	585,745	715

4.2. Data Normalization

In this study using the binary sigmoid activation function, then the values we will use on artificial neural networks will have to be worth 0 to 1. The normalization data formula is as follows (Sya'diyah, 2011):

$$Value\ X_{new} = \frac{Value\ X_{old} - Value\ X_{Minimum}}{Value\ X_{Maximum} - Value\ X_{Minimum}} \quad (1)$$

The results of the data normalization process can be seen in the following table.

Table 2. Normalization Data

F1	F2	F3	F4	F5	F6	F7	F8
X1	0	0	0	0	0,214150	0	0,876571
X2	0,082543	0,037459	0,187036	0,216586	0,526785	0,069001	0,924482
X3	0,388499	0,062246	0,191076	0,393171	0	0,072095	1
X4	0,665504	0,236648	0,159804	0,602100	0,259383	0,049718	0,588160
X5	0,835075	0,167787	0,446863	0,834392	0,089016	0,186776	0,667393
X6	0,928882	0,497360	0,442037	0,989023	0,302954	0,199225	0,297219
X7	0,946880	0,603846	0,631093	1	0,439732	0,325179	0,232189
X8	0,940755	0,952204	0,868505	0,929013	0,857236	0,769266	0
X9	0,952489	0,967543	0,919457	0,958767	0,954121	0,927072	0,011209
X10	1	1	1	0,978412	1	1	0,036830

F9	F10	F11	F12	F13	F14	F15
0,218836	0,313216	0,929093	0	0,771887	0	0,649402
1	0,295801	1	0,202042	1	0,033534	0,119522
0,025647	0,303518	0,952729	0,067348	0,797910	0,075633	0,553785
0,090972	0,101956	0,679815	0,228084	0,731721	0,174001	1
0	0,026151	0,371391	0,498285	0,211981	0,554279	0,749004
0,424087	0	0,250398	0,539746	0	0,864672	0,466135
0,297020	0,021894	0	0,787412	0,033962	0,918926	0,394422

0,181731	0,878778	0,630138	1	0,318136	1	0
0,203015	0,899136	0,392212	0,884479	0,093259	0,921732	0,153386
0,270415	1	0,511175	0,942239	0,205697	0,960865	0,183267

4.3. Artificial Neural Network Design

In this study an artificial neural network architecture will be made using the backpropagation algorithm to predict the price of oil palm FFB in Riau Province which can be seen in the following figure:

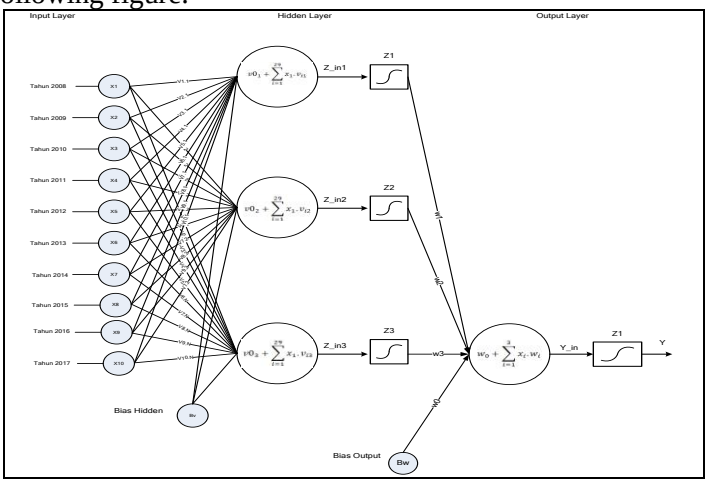


Figure 2. Artificial Neural Network Architecture

4.4. Training and Testing

In this study an experiment of several artificial neural network architectures with different parameter settings was conducted. This is done to get the best neural network architecture and parameters.

Table 3. Experiment of Several ANN Architectures

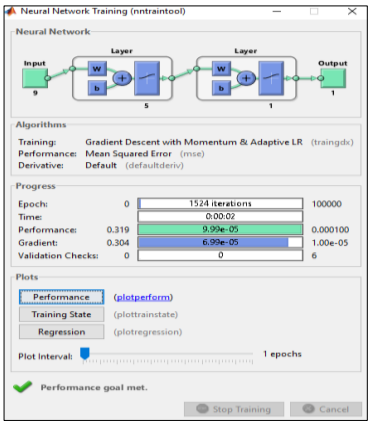
Architectural Pattern	Parameter			Training Result					
	Learning Rate	Goal	Training Function	Epoch	Time	MSE	Gradient	Regression	Accuracy
Pola 9 - 3 - 1	0,01	0,01	Logsig Logsig Traingdx	144	0:00:01	0,0096506	0,0086506	0,96475	96,475 %
	0,001	0,001	Logsig Logsig Traingdx	238	0:00:00	0,0009922	0,00064615	0,99649	99,649 %
	0,0001	0,0001	Logsig Logsig Traingdx	1.083	0:00:01	0,0095941	0,00027638	0,99899	99,899 %
Pola 9 - 5 - 1	0,01	0,01	Logsig Logsig Traingdx	158	0:00:02	0,0094527	0,23939	0,96585	96,585 %
	0,001	0,001	Logsig Logsig Traingdx	364	0:00:00	0,00099676	0,00025621	0,99635	99,635 %
	0,0001	0,0001	Logsig Logsig Traingdx	1.524	0:00:02	**0,0000699**	0,00099905	**0,99970**	**99,970 %**

From the table above it can be seen that the best artificial neural network architecture is with patterns 9 - 5 - 1 using the learning rate parameter 0,0001, goal 0,0001, training

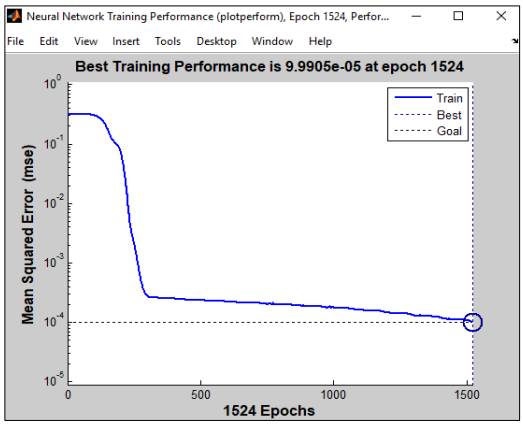
function Logsig - Logsig - Traingdx. The following are the results of the training and testing using the pattern architecture

Table 4. Result for 9-5-1 ANN Architecture

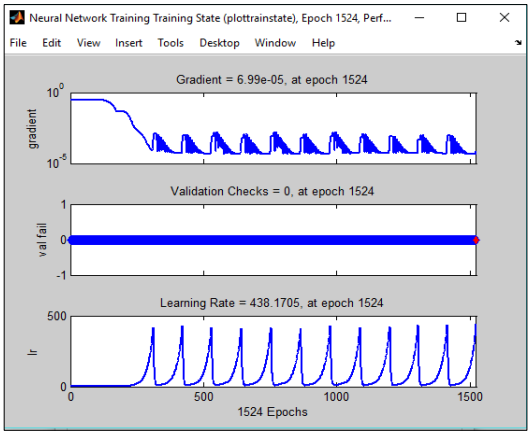
Parameter	Results
1. Learning Rate / Goal = 0,0001 / 0,0001 2. Maximum Epochs = 100.000 3. Function = *Logsig – Logsig – Traingdx*	1. Meet Goal on Epochs ke = 1.524 2. Time Duration = 0 : 00 : 02 3. Performance= 0,000999 4. Gradient = 0,000699 5. Percentation of Acuration = 99,97 %



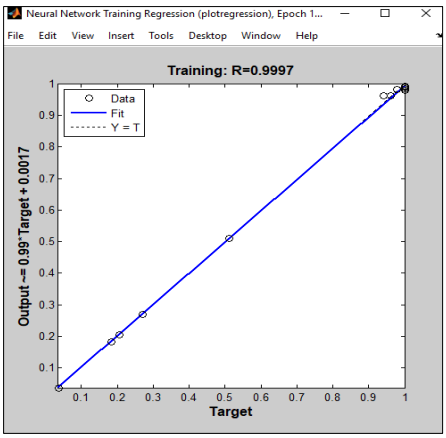
a. Neural Network Training 9-5-1 (c)



b. Neural Network Training Performance 9-5-1 (c)



c. Neural Network Training State 9-5-1 (c)



d. Neural Network Training Regression 9-5-1 (c)

Figure 3. Neural Network Training Results

Table 5. Comparison for Output and Target Value

Y	0,9800	0,9892	0,9844	0,9826	0,9908	0,9907	0,0359	0,2704	0,9921	0,5111	0,9617	0,2055	0,9634	0,1833
T	1,0000	1,0000	1,0000	0,9784	1,0000	1,0000	0,0368	0,2704	1.,0000	0,5112	0,9422	0,2057	0,9609	0,1833

4.5. Prediction Results and Data Denormalization

The following are the results of the prediction of the price of oil palm FFB in Riau Province using the data denormalization formula.

$$x_i = y_n(x_{max} - x_{min}) + x_{min}$$

Table 6. Prediction Result for Area of Riau Palm Oil Plantation

	Year	Area of Riau Palm Oil Plantation (Ha)		
		People's Plantation	State Plantation	Private Plantation
	F_1	F_2	F_3	F_4
Prediction	X_1	845.232	74.721	562.402
	X_2	889.916	75.395	646.846
	X_3	1.055.543	75.841	648.670
	X_4	1.205.498	78.979	634.551
	X_5	1.297.294	77.740	764.154
	X_6	1.348.076	83.670	761.975
	X_7	1.357.819	85.586	847.331
	X_8	1.354.503	91.854	954.519
	X_9	1.360.855	92.130	977.523
	X_{10}	1.386.575	92.714	1.013.887
Yn :		0,9800	0,9892	0,9844
Min :	2008	845.232	74.721	562.402
Max:	2017	1.386.575	92.714	1.013.887
Prediction Result	2018	1.375.748,1400	92.519,6756	1.006.843,8340
Conclusion Comparison with last year (2017)		DECREASE	DECREASE	DECREASE

Table 7. Prediction Result for Riau Palm Oil Production Amount

	Year	Riau Palm Oil Production Amount (Ton)		
		People's Plantation	State Plantation	Private Plantation
	F_1	F_5	F_6	F_7
Prediction	X_1	2.368.076	239.277	2.205.532
	X_2	2.658.044	274.637	2.378.687
	X_3	2.894.459	215.056	2.386.453
	X_4	3.174.176	244.393	2.330.298
	X_5	3.485.172	225.124	2.674.241
	X_6	3.692.195	249.321	2.705.481
	X_7	3.706.891	264.791	3.021.559
	X_8	3.611.853	312.012	4.135.981
	X_9	3.651.687	322.970	4.531.989
	X_{10}	3.677.989	328.159	4.715.000
Yn :		0,9826	0,9908	0,9907
Min :	2008	2.368.076	239.277	2.205.532
Max:	2017	3.677.989	328.159	4.715.000
Prediction Result	2018	3.655.196,5138	327.341,2856	4.691.661,9476
Conclusion Comparison with last year (2017)		DECREASE	DECREASE	DECREASE

Table 8. Prediction Result for Riau Palm Oil Productivity

	Year	Riau Palm Oil Productivity (Kg/Ha)		
		People's Plantation	State Plantation	Private Plantation
	F_1	F_8	F_9	F_{10}
Prediction	X_1	3.775,41	3.898,92	4.362,82
	X_2	3.805,33	4.339,34	4.344,00
	X_3	3.852,49	3.790,00	4.352,34
	X_4	3.595,30	3.826,83	4.134,52
	X_5	3.644,78	3.775,54	4.052,60
	X_6	3.413,61	4.014,64	4.024,34
	X_7	3.373,00	3.943,00	4.048,00
	X_8	3.228,00	3.878,00	4.974,00
	X_9	3.235,00	3.890,00	4.996,00
	X_{10}	3.251,00	3.928,00	5.105,00
Yn :		0,0359	0,2704	0,9921
Min :	2008	3.775,4100	3.898,9200	4.362,8200
Max:	2017	3.251,0000	3.928,0000	5.105,0000
Prediction Result	2018	3.756,5837	3.906,7832	5.099,1368
Conclusion Comparison with last year (2017)		**INCREASE**	**DECREASE**	**DECREASE**

Table 9. Prediction Result for Export of Riau Palm Oil

	Year	Export of Riau Palm Oil (Ton)			
		CPO HC : 1511 10000	OPO HC : 1511 90000	COPK HC : 1513 21000	OCOPK HC : 1513 29000
	F_1	F_{11}	F_{12}	F_{13}	F_{14}
Prediction	X_1	3.786.818	3.196.042	526.585	50.818
	X_2	3.914.362	4.068.195	660.208	69.487
	X_3	3.829.333	3.486.760	541.829	92.924
	X_4	3.338.428	4.180.607	503.057	147.687
	X_5	2.783.650	5.346.979	198.606	359.393
	X_6	2.566.013	5.525.954	74.433	532.193
	X_7	2.115.609	6.595.051	94.327	562.397
	X_8	3.249.072	7.512.725	260.789	607.532
	X_9	2.821.102	7.014.056	129.062	563.959
	X_{10}	3.035.087	7.263.390	194.925	585.745
Yn :		0,5111	0,9617	0,2055	0,9634
Min :	2008	3.786.818	3.196.042	526.585	50,818
Max:	2017	3.035.087	7.263.390	194.925	585,745
Prediction Result	2018	3.402.608,2859	7.107.610,5716	458.428,8700	566.166,6718
Conclusion Comparison with last year (2017)		**INCREASE**	**DECREASE**	**INCREASE**	**DECREASE**

Table 10. Prediction Result for World CPO Prices

	Year	World CPO Prices (Unit : $ / mt)
		The Pink Sheet, World Bank
	F_1	F_{15}
Prediction	X_1	949
	X_2	683
	X_3	901
	X_4	1.125
	X_5	999
	X_6	857
	X_7	821
	X_8	623
	X_9	700
	X_{10}	715
Yn :		0,1833
Min :	2008	949
Max:	2017	715
Prediction Result	2018	906,1078
Conclusion Comparison with last year (2017)		INCREASE

5. Conclusion

After going through the testing phase for artificial neural network architecture using backpropagation algorithm, a conclusion can be drawn:

a. Artificial Neural Networks (ANN) Backpropagation can produce the best architectural patterns in data pattern recognition so that the Artificial Neural Network method can be used to predict the price of Oil Palm FFB in Riau Province.
b. Variable learning rate, the amount of learning data and the weight value used can influence the level of truth predictions so that it needs to be analyzed correctly in using data variables.
c. Based on the results of training and artificial neural network testing, the best architectural model chosen and having the smallest RMSE value is the 9-5-1 architecture with an RMSE error value of 0.0000699, an accuracy percentage of 99.97%. The conclusion of the training and testing of the data shows that the prediction of the price of oil palm FFB in 2018 will increase. And this architectural model can be used for consideration in predicting the price of oil palm FFB in Riau Province.

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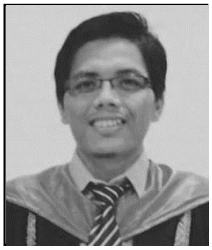
Authors



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ISSN : 2580-7250