Neural Network Enhancement Forecast of Dengue Fever Outbreaks in Coastal Region

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Abstract. Dengue Fever is among the world's fastest-spreading mosquito-borne illnesses. In Indonesia, more than 33 percent of the world community is in danger. The Coastal Zone is one of the regions most at risk of contracting dengue fever, particularly from the social and environmental sectors, so an early diagnostic study must deal with this efficiently and effectively. This research aimed to predict and identify the coastal areas with the most severe dengue fever potential to avoid dengue fever. The methodology used is a neural network-based sensitivity Analysis and multiple linear regression. Bagan Deli, Sibolga, Tapanuli Tengah, Langkat, Medan are samples of the coastal regions used in this study. The reports used was secondary data for dengue fever patients suffering and meteorological parameters, the model used in [5-5-1] for prediction, for five years from 2014-2019. The results showed which Langkat (0.4936), Serdang Bedagai (0.4695), The Middle Of Tapanuli (0.4399), Medan (0.4313), and Sibolga (0.3133) are perhaps the most prevalent areas affected by dengue fever with a value of 89.8 percent. The Result is temperature and humidity are the conditions that most affect the transmission of dengue fever.

1. Introduction
Dengue fever presented as the world's most mosquito-borne severe infectious disease. Dengue vectors bite, probably Aedes aegypti albopictus. Infected by an infected mosquito, the patient may experience a sudden fever that correlates with muscle aches, joints, pain, headache, nausea, and vomiting [1]. Patients with severe cases of DHF can also experience DSS [2]. Children with DENV infection can develop DHF or DSS. As big as 10-20% and more than 40% if. Gibbons & Vaughn, 2002 [3] recorded DSS of mortality in DHF. Unfortunately, dengue fever has no apparent cure or vaccine. People nowadays use dengue vector control (e.g., Aedes mosquito) to avoid outbreaks of dengue fever. Thus, dengue fever has become a significant public health concern for over half of the world's population, particularly in coastal regions, and is a significant cause of hospitalization and death, especially for children in endemic countries — Guzman dan Kouri (2002) [4]. The number of dengue cases in Indonesia rises every year and now recognized as a
significant public health concern. According to Health Ministry numbers, sufferers hit 5,713 people on the North Sumatra Coast in 2019, 25 people died, and coastal areas have a high capacity to transmit this disease. The tackled the spread of dengue fever in Indonesia, especially in the coastal regions of North Sumatra, research needed to predict the areas with the highest rates of dengue fever to recommend the government and society to prioritize these areas so that handle and maximized. In [5] Dengue Hemorrhagic Fever (henceforth DHF) is diagnosed based on medical record by using naïve bayes method. They used 31 parameters namely gender, petechiae, rash or bruising, ecchymosis, bleeding conjunctiva, nosebleeds, bleeding gums, vomit, melena, blood urine, cold tiptoes and hands, bluish skin, palpable pulses, muscle aches, decreased appetite, weakness, nausea, abdominal pain, diarrhea, constipation, loss of consciousness, age, fever, blood pressure and the difference in pulse pressure. The initial diagnosis which resulted help medical team to prevent DFH spreading to another human.

2. Research Objective
The Research Objective of this study is to determine coastal areas with the potential to spread dengue fever. Next is to predict the spread of dengue fever in nearshore regions to combat dengue fever in the coastal regions of North Sumatra. This research is significant because currently, the coastal community has not paid much attention to preventing dengue fever. Besides, the local government is still having difficulty determining dengue fever's priority areas, especially in North Sumatra. Furthermore, dengue fever prediction currently only focuses on the variable number of patients infected with dengue fever. A more in-depth analysis is needed using other variables such as weather factors, social factors, and environmental factors in an integrated manner so that the results obtained are more optimal and more accurate.

3. Literature Review
Artificial Neural Networks was create a learning method to solve pattern recognition or classification problems. Like biological neurons, Artificial Neural Networks are two-way fault-tolerant systems. Next, it can interpret a significantly different input signal than previously obtained. Neural Network is one of the most precise prediction methods used for prediction cases with an average accuracy level of above fifty percent [6]. Coastal is the same as coastal is the meeting place of ground and sea; landward, including areas of land, either dry or immersed in air, may also be said of the sea features, such as waves, sea breezes, and saltwater flow.

Table 1. Literature Review

| Techniques | Author | Year | Disease | Country | Resource Dataset | Tool | Accuracy |
|------------|--------|------|---------|---------|-----------------|------|----------|
| Bayesian | Dr. Arun Kumar, P.M. Associate Professor, 1. Chitra Devi, B. 2. Ganesan.M and 3. Madhan.A.S[8] | 2010 | Dengue Fever | Singapore | NEA (Singapore national Environment | Matlab | 0.91 |
| REP Tree | | | | | Google | WEKA and Netbeans | 0.92 |
| Random Tree | | | | | | 0.76 |
| J48 | | | | | | 0.76 |
| SMO | | | | | | 0.88 |
| ANN | | | | | | 0.76 |
### Table 2. Summary of research Gap, Accuracy, Variable and performance

| Prediction Aspect | Method         | Author | Research GAP Or Limitation | Accuracy | Variable | Performance |
|-------------------|----------------|--------|----------------------------|----------|----------|-------------|
| Prediction        | KNN            | [10]   | Prediction Results Still not consistent and performance is still slow. | Middle   | High     | Low         |
|                   |                | [11][12][13][14],[15][16]–[18] | | | | |
| Prediction        | ANN            | [22][25][15][26] | Accuracy rate reaches 90%, but performance is still slow | High     | Middle   | Low         |
|                   |                | | | | | |
| Prediction        | Genetic Algorithm | [15][27][28][1] | Accuracy level is still a low but good performance | Low      | Middle   | High         |
|                   |                | | | | | |

### 4. Methodology

In this study, the research methodology is used in this case is the backpropagation algorithm network, which consists of a. The input layer with 5 nodes is (x1, x2, x3, x4, x5) and 9 nodes (x1, x2… x9). The hidden layer with the number of vertices specified by the user is one node or one hidden with two neurons, i.e. (y1, y2, y3). The output layer with one node is the prediction accuracy Prediction of dengue fever in coastal areas. This research's material is the Neural Network Backpropagation Algorithm with Matlab software as an analysis tool using variable data. The research. In this analysis, the approach is to gather data. The data used in this report was secondary data taken by the meteorological agency and North Sumatra Central Statistics Bureau. There are also main statistics, namely interviewing data with a survey of coastal communities from 5 cities in North Sumatra's coastal district. The next step is to specify the model to use, namely the model (5-5-1), five input layers, five hidden layers, and one output layer. This choice is choosing because there were experiments with several other models; it was knowing that the model (5-5-1) was a better model seen from RMSE, difference, and accuracy. Next is choosing priority areas for dengue fever using sensitivity analysis and multiple linear regression. The research methodology as described on Figure 1.
5. Result and Discussion
From the research results, it founded that the most dominant areas affected by dengue fever were Langkat (0.4936), Serdang Bedagai (0.4695), Middle Tapanuli (0.4399), Medan (0.4313), and Sibolga (0.3133) with an accuracy value of 89.8%. The detailed information as describe on Table 3.

Table 3. Result Prediction Neural Network

| Input Factors       | Prediction 2019 | Real Result | Accuracy | Difference | Prediction 2020 |
|---------------------|-----------------|-------------|----------|------------|-----------------|
| X1: Medan,          | 0.5240          | 0.4973      | 97.33    | 0.0267     | 0.4313          |
| X2: Serdang Bedagai | 0.5471          | 0.3341      | 78.7     | 0.2130     | 0.4695          |
| X3: Sibolga         | 0.5083          | 0.3388      | 83.06    | 0.1694     | 0.3133          |
| X4: Tapanuli Tengah | 0.5267          | 0.475       | 94.83    | 0.0571     | 0.4399          |
| X5: Langkat,        | 0.5300          | 0.4817      | 95.17    | 0.0483     | 0.4936          |
| **Average Error**   | **95.17**       | **95.17**   | **0.0483** | **89.818** |                 |
Table 4. Result Prediction using Regression

| Input Factors | Partial Sensitivity | Sig 5% | Simultane | Sig 1% |
|---------------|---------------------|--------|-----------|--------|
| X1 = Temperature | 3.314 | 1 | .005 | 0.849 | 0.014 |
| X2 = Humidity | 1.655 | 2 | .120 |          |        |
| X3 = Rainfall Index | -.099 | 5 | .922 |          |        |
| X4 = Wind | .459 | 4 | .653 |          |        |
| X5 = Air Pressure | -.630 | 7 | .539 |          |        |
| X6 = Sunlight | -.485 | 6 | .635 |          |        |
| X7 = Population density | -2.462 | 10 | .027 |          |        |
| X8 = Income | 1.249 | 3 | .232 |          |        |
| X9 = Social Factors | -1.159 | 9 | .266 |          |        |
| X10 = Environment | -.877 | 8 | .396 |          |        |

Table 4 has explained the result of parameters are used in this research. This parameter is used based on previous research [29], which is seen only from weather factors such as air pressure, temperature rainfall index. Furthermore, this research adds to other factors such as social and environmental factors from multiple linear regression measurements. It found that the factors that most influence the spread of dengue fever are temperature (1), then humidity (2), income (3), wind (4), Rainfall Index (5), Sunlight (6), Population Density, Air Pressure (7), Environment (8), Social factors (9), Population Density (10). Overall, all factors affect 0.849 or 84.9% of the spread of dengue fever in coastal areas.

6. Conclusion

The conclusions are as follows the most dominant areas affected by dengue fever are Langkat (0.4936), Serdang Bedagai (0.4695), Middle Tapanuli (0.4399), Medan (0.4313), and Sibolga (0.3133) with an accuracy value of 89.8%. The results showed that the priority areas with the highest prevalence of dengue fever were Langkat and Serdang Bedagai, so that these areas needed more optimal handling to combat dengue fever by both the community and local government. The factors that most influence the spread of dengue fever are temperature (1), then humidity (2), income (3), wind (4), Rainfall Index (5), Sunlight (6), Population Density, Air Pressure (7), Environment (8), Social factors (9), Population Density (10). Overall, all factors affect 0.849 or 84.9% of the spread of dengue fever in coastal areas. Furthermore, the most influential factor is the community's humidity and income for the spread of dengue fever, so that the government recommends paying more attention to this factor, and there is further treatment.
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References

[1]. M. Cabrera and web-support@bath.ac.uk Spatio-Temporal modeling of Dengue Fever in Zulia state, Venezuela 2014.
[2]. D Fernando, N L De Silva, I Ackers, R Abeyasinghe, P Wijeyaratne, and S Rajapakse 2014 Patient satisfaction and uptake of private-sector run malaria diagnosis clinics in a post-conflict district in Sri Lanka BMC Public Health
[3]. Potts J A, Gibbons R V, Rothman A L, Srikiatkhachorn A, Thomas S J, Supradish P, Lemon S C, Libraty D H, Green S, Kalayanarooj S 2010 Prediction of dengue disease severity among Thai pediatric patients using early clinical laboratory indicators PLoS Negl. Trop. Dis.
[4]. Beatty M E, Stone A, Fitzsimons D W, Hanna J N, Lam S K, Vong S, Guzman M G, Mendez-Galvan J F, Halstead S B, Letson G W, Kurtsky I J, Mahoney R, and Margolis H S 2010 Best practices in dengue surveillance: A report from the Asia-Pacific and Americas dengue prevention boards," PLoS Negl. Trop. Dis., 4 11
[5]. Suparman C A R, Purwanti E, and Widiyanti P 2017 Application Design of Dengue Hemorrhagic Fever Patients Screening Using Naive Bayes Method J. of Biomimetics, Biomaterials and Biomedical Engineering 34 p.20-28
[6]. E. Fernandez 2015 Predictive Models for dengue fever and severe dengue in Honduras and the National Classification agreement with the two most recent international guidelines on severe dengue p. 138
[7]. Iqbal M, Zarlis M, and Harumy T H F 2017 Inovasi Aplikasi Check In Spot nelayan binaan Kecamatan Bagan Deli Medan Seminar Nasional APTIKOM pp. 1–6.
[8]. Kumar A P M, Chitra D, Karthick P, Ganesan M, and Madhan A S 2017 Dengue Disease Prediction Using Decision Tree and Support Vector Machine SSGR Int. J. Comput. Sci. Eng
[9]. Qing C 2012 A study of the species diversity of landscape trees on three university campuses from Inner Mongolia Acta Hortic.937 6 pp. 1141–1146
[10]. Anugraha A, Vinodha E, Anusha R, Giridhar S, and Narasimhan K 2017 A Machine Learning Application for Epileptic Seizure Detection 3rd Int. Conf. Cloud Comput. Technol. Appl. (CloudTech)17
[11]. Bhattacharjee S and Singh Y J 2017 Comparative Performance Analysis of Machine Learning Classifiers on Ovarian Cancer Dataset 2017 Third Int. Conf. on Res. in Computational Intelligence and Communication Networks (ICRCICN) pp 213-218
[12]. Rodrigues C N M, Gonçalves A B, Silva G G, and Pistori H 2015 Evaluation of Machine Learning and Bag of Visual Words Techniques for Pollen Grains Classification, IEEE Lat. Am. Trans.
[13]. Hossain F M T, Hossain M I, and Nawshin S 2017 Machine learning based class level prediction of restaurant reviews in 2017 IEEE Region 10 Humanitarian Technol. Conf. (R10-HTC).
[14]. Chowdhury S R 2014 Automated Segmentation and Pathology Detection in Ophthalmic Images p. 219
[15]. Images S, Mobile U, and Reni S K 2014 Automated Low-Cost Malaria Detection System in Thin Blood Slides Images Using Mobile Phones
[16]. Gupta S, and Manjhvar A K 2017 Relation classification from unstructured medical text using feature based machine learning approach Proc. - Int. Conf. Trends Electron. Informatics, ICEI 2017, pp. 1135–1138

[17]. Pal R, Poray J and Sen M 2017 Application of machine learning algorithms on diabetic retinopathy 2017 2nd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT) pp. 2046-2051

[18]. Pannu H S and Jarial P 2017 Machine learning techniques for bleeding detection in capsule endoscopy 2017 International Conference on Computing Methodologies and Communication (ICCMC) pp. 1054-1058, doi: 10.1109/ICCMC.2017.8282632.

[19]. Zhu G , Hunter J, and Jiang Y 2016 Improved Prediction of Dengue Outbreak Using the Delay Permutation Entropy; Proc. - 2016 IEEE Int. Conf. Internet Things; IEEE Green Comput. Commun. IEEE Cyber, Phys. Soc. Comput. IEEE Smart Data, iThings-GreenCom-CPSCom-Smart Data 2016, pp. 828–832

[20]. Joung J 2016 Machine Learning-Based Antenna Selection in Wireless Communications IEEE Commun. Lett

[21]. A. Sau and I. Bhakta, "Predicting anxiety and depression in elderly patients using machine learning technology," Healthc. Technol. Lett., 2017.

[22]. Wickramasinghe M P N M, Perera D M, and Kahandawaarachchi K A D C P 2017 Dietary prediction for patients with Chronic Kidney Disease (CKD) by considering blood potassium level using machine learning algorithms 2017 IEEE Life Sciences Conference (LSC), Sydney NSW 2017 pp. 300-303

[23]. Cesare N, Grant C, Hawkins J B, Brownstein J B, and Nsoesie E O 2017 Demographics in Social Media Data for Public Health Research: Does it matter? in bloomberg Data for Good Exchange Conference pp. 1–8

[24]. Dai X and Bikdash M, "Hybrid classification for tweets related to infection with influenza," in Conf. Proc. - IEEE SOUTHEASTCON, 2015

[25]. Alharthi H ARTICLE IN PRESS G 2018 Model Healthcare predictive analytics: An overview with a focus on Saudi Arabia J. Infect. Public Health

[26]. Choudhury Z M A H, Banu, Shahera and Islam, Amirul M 2008 Forecasting dengue incidence in Dhaka, Bangladesh: A time series analysis Dengue Bull. 32 pp. 29–37

[27]. Yusof Y and Mustaffa Z 2011 Dengue Outbreak Prediction: A Least Squares Support Vector Machines Approach Int. J. Comput. Theory Eng 3 4 pp. 489–493

[28]. Huang J, Zheng H, Wang H and Jiang X 2017 Machine Learning Approaches for Cyanobacteria Bloom Prediction using metagenomic sequence data, a case study IEEE Int. Conf. Bioinforma. Biomed.

[29]. Bjorge S S, Siddiqui W, Chung C, Morens D, Smith K R and Lewis N 1995A Study of Determinants of Malaria in Kelantan, Malaysia pp. 1–101