



**UNDERGRADUATE THESIS**

**IMPLEMENTATION OF AN IOT-BASED  
RAINFALL PREDICTION SYSTEM USING LORA  
AND EXTREME GRADIENT BOOSTING  
(XGBOOST)**

**M. ARIF**

NPM 21081010199

**THESIS ADVISORS**

Dr. Ir. Mohammad Idhom, SP., S.Kom., MT.

Henni Endah Wahanani, ST. M.Kom.

**MINISTRY OF HIGHER EDUCATION, SCIENCE, AND TECHNOLOGY  
UNIVERSITAS PEMBANGUNAN NASIONAL VETERAN JAWA TIMUR  
FACULTY OF COMPUTER SCIENCE  
INFORMATICS STUDY PROGRAM  
SURABAYA  
2026**

**APPROVAL SHEET**

**IMPLEMENTATION OF AN IOT-BASED RAINFALL PREDICTION  
SYSTEM USING LORA AND EXTREME GRADIENT BOOSTING  
(XGBOOST)**

**By:**

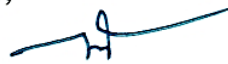
**M. ARIF**

**NPM. 21081010199**

Has been defended before, and accepted by, the Board of Assessors of the Thesis Examination of the Informatics Study Program, Faculty of Computer Science, Universitas Pembangunan Nasional Veteran Jawa Timur, on April 1, 2026:

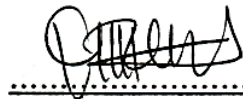
**Approved,**

**Dr. Ir. Mohammad Idhom, SP., S.Kom., MT.**  
NIP. 19830310 202121 1 006



..... (Advisor I)

**Henni Endah Wahanani, ST. M.Kom.**  
NIP. 19780922 202121 2 005



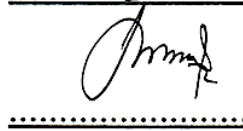
..... (Advisor II)

**Dr. Rizky Parlita, S.Kom, M.Kom.**  
NIP. 19840518 202121 1 003



..... (Head Assessor)

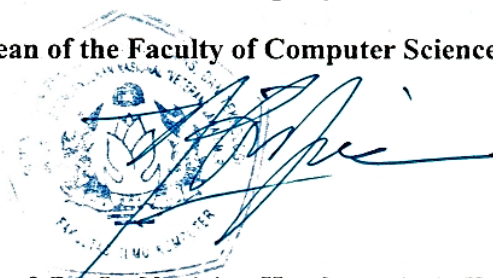
**Achmad Junaidi, S.Kom., M.Kom.**  
NIP. 197811102025211048



..... (Assessor I)

**Acknowledge by,**

**Dean of the Faculty of Computer Science**



**Prof. Dr. Ir. Novirina Hendrasarie, MT.**  
NIP. 19681126 199403 2 001

**APPROVAL SHEET**

**IMPLEMENTATION OF AN IOT-BASED RAINFALL PREDICTION  
SYSTEM USING LORA AND EXTREME GRADIENT BOOSTING  
(XGBOOST)**

By:

**M. ARIF**

**NPM. 21081010199**

Approved to proceed to the Thesis Examination

**Approved by,**

**Coordinator of Informatics Study Program  
Faculty of Computer Science**



**Dr. Intan Yuniar Purbasari, S.Kom. MSc.**  
**NIP. 19800602 202521 2 029**

## STATEMENT OF ORIGINALITY

I am the undersigned:

Student Name : M. Arif  
NPM : 21081010199  
Degree Program : Bachelor (S1)  
Study Program : Informatics  
Faculty : Faculty of Computer Science

Hereby declares that this undergraduate thesis contains no part of any other scientific work that has been submitted to obtain an academic degree at any higher education institution. Furthermore, it does not contain any work or opinions previously written or published by others, except for those which are explicitly cited in this thesis and listed completely in references.

And I declare that this scientific document is free from elements of plagiarism. If in the future indications of plagiarism are found in this Thesis, I am willing to accept sanctions in accordance with the applicable laws and regulations.

- Thus, I made this statement without any coercion from anyone and to be used as it should.



Surabaya, April 7, 2026

Declarant,



M. ARIF

NPM. 21081010199

## ABSTRACT

Student Name / NPM: M. Arif/21081010199  
Thesis Title: Implementation of an IoT-Based Rainfall Prediction System Using LoRa and Extreme Gradient Boosting (XGBoost)  
Supervisor: 1. Dr. Ir. Mohammad Idhom, SP., S.Kom., MT.  
2. Henni Endah Wahanani, ST. M.Kom

Unpredictable weather conditions caused by climate variability present major challenges for the agricultural sector, particularly in determining farming activities such as irrigation and pesticide spraying. Limited access to real-time weather information in rural areas further increases the risk of agricultural losses. Therefore, this study proposes an Internet of Things (IoT)-based rainfall prediction system integrated with LoRa communication and the Extreme Gradient Boosting (XGBoost) algorithm. The developed system consists of an Arduino Uno R3, SHT31 sensor, anemometer, LoRa SX1278 module, ESP32 gateway, and AWS EC2 cloud server using the MQTT protocol. InfluxDB and Grafana are utilized for data storage and monitoring. The prediction model is trained using historical BMKG weather data from 2020–2025 with input features consisting of TN, TX, TAVG, RH\_AVG, FF\_X, and FF\_AVG. Rainfall is categorized into four classes: No Rain, Light Rain, Moderate Rain, and Heavy Rain. Testing results show that the LoRa communication system operated reliably with RSSI values ranging from  $-81.88$  dBm to  $-74.58$  dBm and SNR values ranging from 9.70 dB to 9.96 dB at a testing distance of approximately 483 meters. The Packet Loss Rate (PLR) remained relatively low, indicating stable data transmission. The XGBoost model achieved an accuracy of 74% with weighted precision, recall, and F1-score values of 0.70, 0.74, and 0.71, respectively. Overall, the developed system supports real-time environmental monitoring and rainfall prediction for agricultural applications. **Keywords:** Internet of Things (IoT), LoRa, XGBoost, rainfall prediction, MQTT, environmental monitoring.

## ACKNOWLEDGEMENTS

Praise be to Allah SWT for His mercy, guidance, and blessings, which have enabled the author to successfully complete this undergraduate thesis entitled “Implementation of an IoT-Based Rainfall Prediction System Using LoRa and Extreme Gradient Boosting (XGBoost)”.

The purpose of this undergraduate thesis is to fulfill one of the requirements for completing the Bachelor’s Degree (S1) in the Informatics Study Program, Faculty of Computer Science, Universitas Pembangunan Nasional “Veteran” Jawa Timur.

On this occasion, the author would like to express sincere appreciation and deepest gratitude to all parties who have contributed to the completion of this undergraduate thesis, especially to:

1. Prof. Dr. Ir. Akhmad Fauzi, MMT., IPU., as the Rector of Universitas Pembangunan Nasional “Veteran” Jawa Timur.
2. Prof. Dr. Ir. Novirina Hendrasarie, M.T., as the Dean of the Faculty of Computer Science, Universitas Pembangunan Nasional “Veteran” Jawa Timur.
3. Dr. Intan Yuniar Purbasari, S.Kom. MSc., as the Coordinator of the Informatics Study Program, Faculty of Computer Science, Universitas Pembangunan Nasional “Veteran” Jawa Timur.
4. Dr. Ir. Mohammad Idhom, S.P., S.Kom., M.T., as Thesis Advisor I, for the guidance, advice, and support provided throughout this research.
5. Henni Endah Wahanani, S.T., M.Kom., as Thesis Advisor II, for the guidance, advice, and support provided throughout this research.
6. Dr. Rizky Parlika, S.Kom., M.Kom., as Examiner I, for the valuable insights and perspectives given to improve this research.
7. Achmad Junaidi, S.Kom., M.Kom., as Examiner II, for the valuable insights and perspectives given to improve this research.
8. Dr. Ir. Kartini, S.Kom., M.T., as Academic Advisor, who has provided guidance and valuable advice to the author throughout the academic journey and during the completion of this research.
9. All lecturers and staff of the Informatics Study Program, Universitas Pembangunan Nasional “Veteran” Jawa Timur, for their guidance, knowledge,

and assistance provided to the author throughout the academic journey and during the preparation of this thesis.

10. The author's parents, who have always played an important role in the author's life journey. Thank you for your sincere support, both materially and emotionally, for always being a place to return to during difficult times, and for continuously providing prayers and encouragement that became an endless source of strength for the author in completing this thesis. Their advice and exemplary values have also become an important foundation for the author to become a responsible, hardworking, and resilient person in facing every process of life.
11. Friends, close friends, and the author's closest people who have provided support, assistance, motivation, and encouragement throughout the process of completing this thesis. The author would like to express sincere gratitude for all the care, togetherness, and support given during the academic journey until the completion of this thesis.
12. All parties who cannot be mentioned one by one, the author would like to express sincere gratitude for all support, assistance, and suggestions provided during the completion of this thesis.

The author realizes that there are still many shortcomings in the preparation of this thesis. Therefore, constructive criticism and suggestions from various parties are highly expected in order to improve this thesis. Finally, with all the limitations possessed by the author, it is hoped that this thesis will be beneficial for all parties in general and for the author in particular.

Surabaya, April 7, 2026



M. Arif

## TABLE OF CONTENTS

<b>APPROVAL SHEET .....</b>	<b>iii</b>
<b>APPROVAL SHEET .....</b>	<b>v</b>
<b>STATEMENT OF ORIGINALITY .....</b>	<b>vii</b>
<b>ABSTRACT .....</b>	<b>ix</b>
<b>ACKNOWLEDGEMENTS.....</b>	<b>xi</b>
<b>TABLE OF CONTENTS.....</b>	<b>xiii</b>
<b>LIST OF FIGURES .....</b>	<b>xvi</b>
<b>LIST OF TABLES .....</b>	<b>xviii</b>
<b>CHAPTER I INTRODUCTION.....</b>	<b>1</b>
1.1    Background .....	1
1.2    Research Problems .....	3
1.3    Research Objectives .....	4
1.4    Research Benefits.....	4
1.4.1    For the Author .....	4
1.4.2    For Readers .....	4
1.4.3    For Farmers and Agricultural Practitioners.....	4
1.5    Research Limitations.....	5
<b>CHAPTER II LITERATURE REVIEW .....</b>	<b>6</b>
2.1    Previous Studies .....	7
2.2    Theoretical Foundation .....	10
2.2.1 <i>Internet of Things</i> (IoT).....	10
2.2.2    Amazon EC2 .....	11
2.2.3    ESP32-WROOM-32 .....	13
2.2.4    Arduino Uno R3 .....	14
2.2.5    LoRa SX1278.....	15
2.2.6    SHT31 Sensor .....	16
2.2.7    Anemometer .....	17
2.2.8    MQTT Mosquito .....	18
2.2.9    Node-RED.....	19
2.2.10    InfluxDB .....	19
2.2.11    Grafana.....	20

2.2.12	BMKG Dataset and Prediction Basis.....	20
2.2.13	Weather Parameters Affecting Rainfall .....	22
2.2.14	Extreme Gradient Boosting (XGBoost).....	22
<b>CHAPTER III SYSTEM DESIGN AND IMPLEMENTATION.....</b>		<b>25</b>
3.1	Research Flow .....	25
3.2	Problem Identification.....	26
3.3	Literature Review .....	26
3.4	System Requirements Analysis.....	27
3.4.1	Hardware Requirements.....	27
3.4.2	Software .....	28
3.4.3	Data .....	28
3.5	Data Collection.....	29
3.6	System Architecture Design Scheme .....	29
3.7	System Automation Scenario and Flowchart.....	30
3.8	System Integration and Data Transmission Flow .....	34
3.9	Selection of Weather Parameters as Model Features.....	34
3.10	XGBoost Implementation Scheme.....	35
3.8.1	Input data.....	39
3.8.2	Output.....	40
3.11	Test Object .....	40
3.12	System Testing .....	40
<b>CHAPTER IV RESULTS AND DISCUSSION .....</b>		<b>43</b>
4.1	Hardware Design Implementation .....	43
4.1.1	Implementasi Rancangan Node sensor (Transmitter).....	43
4.1.2	Implementation of the Gateway Design (Receiver).....	44
4.2	Software Implementation .....	45
4.2.1	Arduino Uno Program Implementation .....	45
4.2.2	ESP32 Program Implementation.....	49
4.2.3	MQTT Mosquitto Implementation.....	56
4.2.4	Node-RED Implementation .....	58
4.2.5	InfluxDB Implementation .....	59
4.2.6	Grafana Implementation.....	61

4.2.7	AWS EC2 Automation Implementation .....	62
4.2.8	Implementasi XGBoost.....	64
4.3	System Testing .....	67
4.3.1	LoRa Communication Testing (RSSI and SNR) .....	68
4.3.2	Wi-Fi Connection and MQTT Testing on the Gateway.....	69
4.3.3	Packet Loss Rate (PLR) Testing .....	70
4.3.4	Data Storage Testing on InfluxDB.....	72
4.3.5	Data Monitoring Testing Using Grafana.....	73
4.3.6	End-to-End Testing .....	74
<b>CHAPTER V CONCLUSION AND SUGGESTIONS.....</b>		<b>79</b>
5.1	Conclusion .....	79
5.2	Suggestions .....	80
<b>REFERENCES.....</b>		<b>81</b>
<b>APPENDICES .....</b>		<b>85</b>

## LIST OF FIGURES

Figure 2. 1 IoT Trends .....	11
Figure 2. 2 Illustration of Amazon EC2 Instance Type Naming .....	12
Figure 2. 3 ESP32 .....	13
Figure 2. 4 Arduino Uno R3 .....	14
Figure 2. 5 LoRa SX1278 .....	16
Figure 2. 6 SHT31 .....	17
Figure 2. 7 Anemometer .....	18
Figure 3. 1 Research Flowchart .....	25
Figure 3. 2 Sensor Node Design Scheme (Transmitter) .....	30
Figure 3. 3 Gateway Design Scheme (Receiver) .....	30
Figure 3. 4 System Flowchart .....	33
Figure 3. 5 XGBoost Implementation .....	38
Figure 4. 1 LoRa Sensor Node (Transmitter) Prototype .....	44
Figure 4. 2 LoRa Gateway (Receiver) Prototype .....	45
Figure 4. 3 MQTT Mosquitto Implementation .....	56
Figure 4. 4 Node-RED Implementation .....	58
Figure 4. 5 InfluxDB Implementation .....	59
Figure 4. 6 Grafana Dashboard for Sensor Data and LoRa Signal Monitoring ....	61
Figure 4. 7 Serial Monitor Display When Wi-Fi and MQTT Connections Are Successful.....	70
Figure 4. 8 Serial Monitor Display When Wi-Fi and MQTT Connections Fail ...	70
Figure 4. 9 Sensor Data Stored in the InfluxDB Database .....	72
Figure 4. 10 Daily Sensor Data Monitoring Dashboard on Grafana.....	73
Figure 4. 11 Sensor Node Installation at the Testing Location.....	75
Figure 4. 12 LoRa Gateway Device Used in the System.....	76
Figure 4. 13 Rainfall Prediction Notification via Discord Webhook.....	77

## LIST OF TABLES

Table 2. 1 AWS EC2 Instance Specifications.....	12
Table 2. 2 ESP32 Specifications .....	13
Table 2. 3 Arduino Uno R3 Specifications .....	15
Table 2. 4 Rainfall Intensity .....	21
Table 3. 1 Hardware .....	27
Table 3. 2 Software .....	28
Table 3. 3 System Automation Scenario.....	31
Table 3. 4 Example Dataset for XGBoost Prediction .....	38
Table 3. 5 System Testing Scenarios .....	42
Table 4. 1 Rainfall Intensity Prediction Module Performance .....	65
Table 4. 2 XGBoost Model Feature Importance .....	66
Table 4. 3 LoRa Performance Results Based on RSSI and SNR.....	68
Table 4. 4 Packet Loss Rate (PLR) Testing Results .....	70
Table 4. 5 Daily Rainfall Intensity Predictions and Notification Delivery Status	77