Analysis of Climate Change in Kalasin Province Using Artificial Intelligence Technology

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Abstract

Climate change is a critical factor affecting agriculture, environment, and economy, particularly in climatically vulnerable regions such as Kalasin Province. This study aims to analyze temperature and rainfall trend changes in Kalasin Province between 2021-2024 and forecast trends until 2028 using Artificial Intelligence (AI) technology for climate prediction. The research utilized historical temperature and rainfall data from the Meteorological Department to train AI models, specifically **Long Short-Term Memory (LSTM)** and **AutoRegressive Integrated Moving Average (ARIMA)**. The findings reveal a continuous increasing trend in Kalasin Province's temperature, particularly in the fourth quarter, with an increase of up to 3.12℃. Rainfall demonstrated significant variability, with some years showing a clear decline in early periods and increased precipitation during rainy seasons, potentially influenced by El Niño and La Niña phenomena. Comparing AI model performance, **LSTM** demonstrated higher accuracy than **ARIMA**, as evidenced by lower *Root Mean Square Error (RMSE)* values. The LSTM model showed superior capability in capturing data trends and variations. However, the models still exhibited limitations during periods of rapid climate changes. The study's results can serve as a foundational resource for climate adaptation planning, enabling relevant agencies to develop more effective measures for water resource and agricultural management in Kalasin Province.

Keywords: Climate Change, Kalasin Province, LSTM, Climate Forecasting, Temperature, Rainfall

1. Introduction

Climate change represents a significant global challenge impacting ecosystems, economies, and human quality of life (IPCC, 2021), especially in ecologically vulnerable regions heavily dependent on agricultural sectors. Kalasin Province is one such area with high climate change risk, being a crucial agricultural region dependent on appropriate rainfall and temperature conditions (Meteorological Department, 2023). Currently, Artificial Intelligence (AI) technology plays a critical role in analyzing and predicting climate change trends by efficiently processing large datasets and identifying complex relationship patterns. This study aims to utilize AI models to analyze temperature and rainfall trends in Kalasin Province, generating knowledge that can inform appropriate future adaptation and mitigation strategies.

1.1 Research Objectives

1. Analyze temperature and rainfall trend changes in Kalasin Province between 2021-2024
2. Develop and evaluate AI model performance in predicting future climate changes
3. Forecast climate change trends in Kalasin Province until 2028
4. Analyze potential impacts on agricultural and environmental sectors

2. Methodology

2.1 Data Collection

The study utilized data collected by the Meteorological Department in Kalasin Province, selecting a dataset containing daily average temperature, daily rainfall data from the Nong Muang Subdistrict, Kamalasai District. The dataset covered the period from 2021 to 2024.

- Data features included 4 columns: Average Temperature, Minimum Temperature, Maximum Temperature, Rainfall
- Data spans from January 1, 2021, to December 31, 2024

date	Average Tempe	Minimum Temp	Maximum Tem	rainfall
2021-01-01	17.4	11.7	24.5	0
2021-01-02	18.5	12.3	25	0
2021-01-03	21	13.9	28	0
2021-01-04	22.1	16.6	28.3	0
2021-01-05	23.4	16.8	30.4	0
2021-01-06	23.7	18	29.5	0
2021-01-07	23.5	18	29.8	0
2021-01-08	20.6	14.7	26.1	0
2021-01-09	18	12.9	24.1	0
2021-01-10	18.4	12.4	25.2	0
2021-01-11	17.3	12.3	23.5	0
2021-01-12	15.5	10.8	21.8	0
2021-01-13	16.7	10.2	24.5	0

Figure 1: Example of a data set

2.2 Data Preparation

1. Data cleaning and anomaly removal
2. Splitting data into training and testing sets

2.3 AI Model Development

Utilized three AI models for training:

1. LSTM (Long Short-Term Memory)
2. ARIMA (AutoRegressive Integrated Moving Average)

2.4 Model Performance Evaluation

Analyzed Root Mean Square Error (RMSE) for temperature (℃) and rainfall (mm)

2.5 Future Trend Forecasting

The most effective model was used to predict climate change trends from 2025 to 2028

3. Results

3.1 Historical Climate Change Trends

Table 1: Climate Change Trends in Kalasin Province, 2021-2024

Quarter	Avg Temp (°C)	Min Temp (°C)	Max Temp (°C)	Total Rainfall (mm)
2021Q1	24.57	18.82	31.44	35.6
2021Q2	29.08	25.23	34.66	516.7
2021Q3	27.72	24.59	32.05	957.7
2021Q4	24.72	20.12	30.16	307.4
2022Q1	25.14	19.87	31.63	197.5
2022Q2	27.83	23.71	33.26	524.2
2022Q3	27.04	23.85	31.49	1133.9
2022Q4	24.62	20.02	30.22	211.0
2023Q1	25.01	19.44	31.53	20.1
2023Q2	30.01	25.54	35.72	523.0
2023Q3	27.74	24.55	32.18	1034.4
2023Q4	25.91	21.36	31.38	221.6
2024Q1	26.68	21.21	33.17	56.2
2024Q2	31.43	26.80	36.98	731.4
2024Q3	28.72	25.64	32.81	1034.5
2024Q4	26.20	21.30	32.20	111.9

The data reveals that **the average maximum temperature typically occurs in Quarter 2 (April-June)**, which is Thailand's hot season. Specifically, in Q2 of 2024, the average maximum temperature was **31.43°C** with a daily maximum of **36.98°C**. This may result from increased solar heat energy during the hot season, including the influence of the El Niño phenomenon. Conversely, the lowest temperature quarters are typically **Quarter 1 (January-March)**, the winter season in Thailand. The first quarter of 2021 had the lowest average temperature at **24.57°C**, correlating with cold air masses from China affecting regional weather patterns.

Maximum rainfall occurs in **Quarter 3 (July-September)**, the rainy season. **Q3/2022 recorded the highest rainfall at 1,133.9 mm**, potentially related to the southwest monsoon and tropical cyclones moving through the region. The **lowest rainfall** was observed in **Q1 of 2023 (only 20.1 mm)**, the dry season, possibly due to high-pressure systems creating dry, low-cloud conditions.

3.2 AI Model Performance Comparison

Performance results for models predicting data from 2021 to 2024

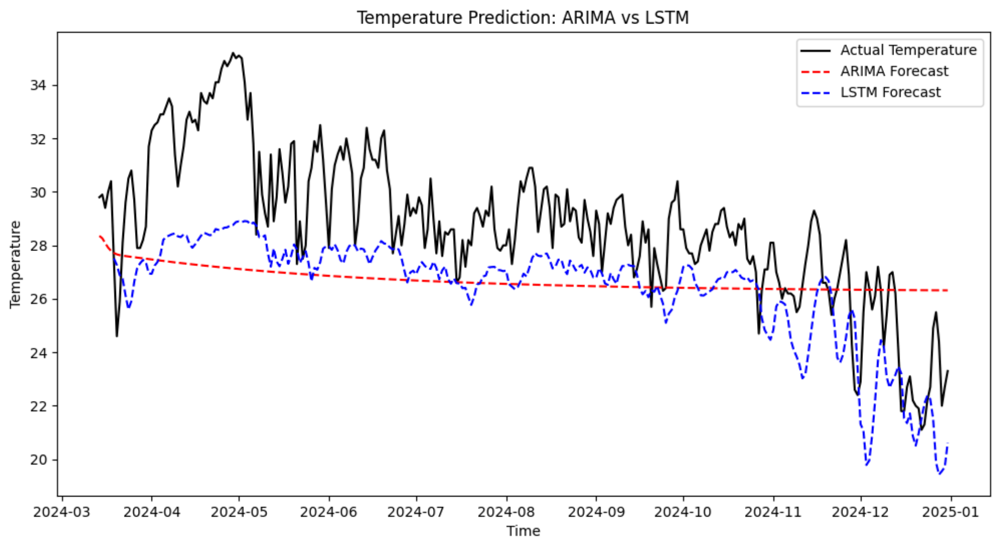

Figure 2: Comparison of Temperature Forecasts from ARIMA and LSTM Models with Actual Temperature Data

Figure 2 presents a comparison between the temperature forecasts generated by the ARIMA and LSTM models against actual temperature data. The ARIMA model produces a relatively smooth trend line with a slight downward tendency compared to actual temperature values, indicating that while the model captures the overall trend effectively, it fails to accurately reflect temperature fluctuations. In contrast, the LSTM model provides forecasts that are more closely aligned with actual temperature data and is better at capturing fluctuations. However, the LSTM model still exhibits some deviations, particularly during the latter part of the year when temperature changes occur more rapidly.

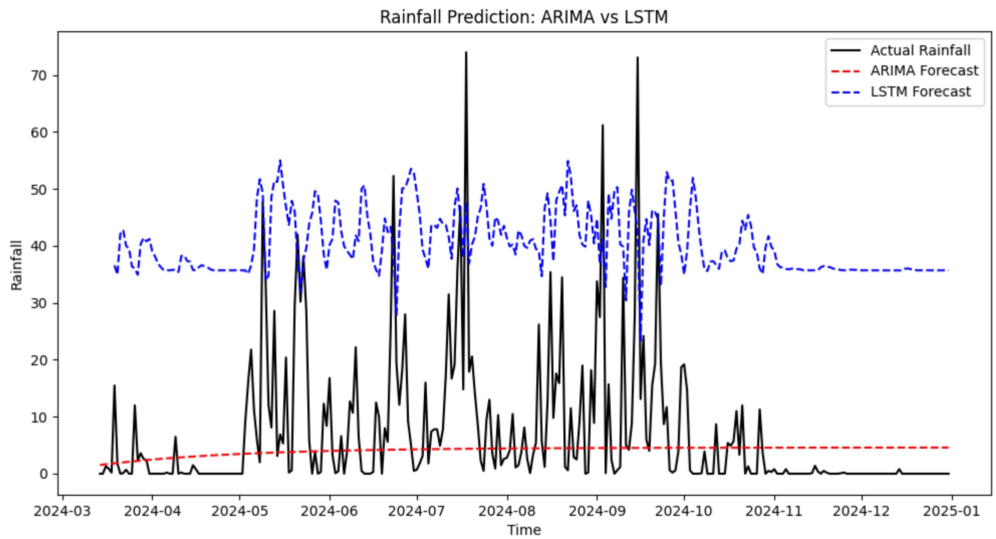

Figure 3: Comparison of Rainfall Forecasts from ARIMA and LSTM Models with Actual Rainfall Data

Figure 3 presents a comparison between the rainfall forecasts generated by the ARIMA and LSTM models against actual rainfall data. The ARIMA model produces a relatively smooth trend line with a slight upward tendency compared to actual rainfall values, indicating that while the model captures the overall trend effectively, it fails to accurately reflect rainfall fluctuations. In contrast, the LSTM model provides forecasts that are more closely aligned with actual rainfall data and is better at capturing fluctuations. However, the LSTM model still exhibits some deviations, particularly during the latter part of the year when rapid changes in rainfall occur.

Table 2: Comparison of AI Model Performance in Weather Prediction

Model AI	RMSE value (°C)	RMSE value (mm.)
LSTM	2.95	12.24
ARIMA	3.29	35.35

The comparison of AI model performance in Tables and Figures demonstrates that the LSTM model consistently outperformed ARIMA, with lower Root Mean Square Error (RMSE) values for both temperature and rainfall predictions.

3.3 Future Trend Forecasting

When the LSTM model is used to predict future climate trends, the results are shown in Table 3.

Table 3: Forecasted Climate Conditions in Kalasin Province from 2025 to 2028 Using the LSTM Model.

Quarter	Year 2025 (Temperature, Rainfall)	Year 2026 (Temperature, Rainfall)	Year 2027 (Temperature, Rainfall)	Year 2028 (Temperature, Rainfall)	Trend (Temperature, Rainfall)
Q1 (Jan-Mar)	26.90℃, 4.96mm	27.77℃, 2.72mm	28.22℃, 1.78mm	28.69℃, -0.38mm	Temperature: +1.79℃, Rainfall: -5.34mm
Q2 (Apr-Jun)	32.83℃, 121.22mm	31.68℃, 98.02mm	29.42℃, 10.46mm	28.87℃, 55.65mm	Temperature: -3.96℃, Rainfall: -65.57mm
Q3 (Jul-Sep)	29.03℃, 261.72mm	31.70℃, 287.67mm	32.36℃, 292.63mm	29.64℃, 260.45mm	Temperature: +0.39℃, Rainfall: -1.27mm
Q4 (Oct-Dec)	27.78℃, 157.30mm	28.61℃, 187.93mm	31.89℃, 210.86mm	30.90℃, 202.24mm	Temperature: +3.12℃, Rainfall: +44.94mm

According to the data in the table, the temperature in each quarter exhibits a continuous upward trend every year. This increase is particularly pronounced in the fourth quarter (October-December), where the most significant rise is observed. Notably, in 2027 and 2028, the average temperature increase reaches approximately 3.12℃ during this period. This change may indicate the impact of climate change, contributing to rising temperatures across various regions worldwide. Regarding rainfall, a continuous decline is observed in some quarters, particularly in the first quarter (January-March). For instance, in early 2028, rainfall decreases significantly, indicating prolonged dry periods. However, in the third (July-September) and fourth (October-December) quarters, rainfall increases in certain years. Notably, in 2027 and 2028, there is a substantial rise in precipitation during the last quarter. This fluctuation may reflect regional climatic variations, leading to inconsistent rainfall distribution patterns across different years.

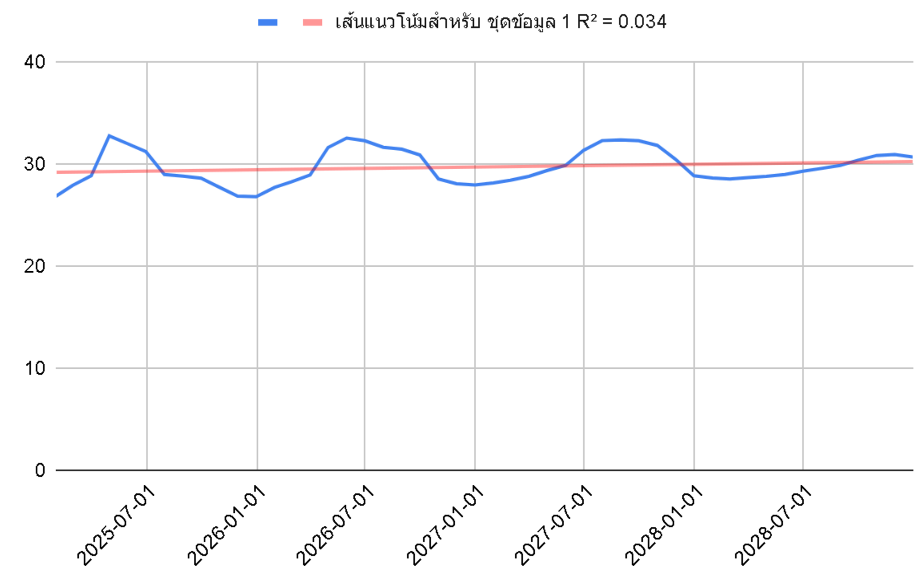

Figure 4: Temperature Trend Graph

Figure 4 illustrates the monthly temperature trends over different periods from 2025 to 2028. The red trend line indicates an increasing pattern, with an **R^2 value of 0.034**, suggesting a slight upward trend in temperature over time.

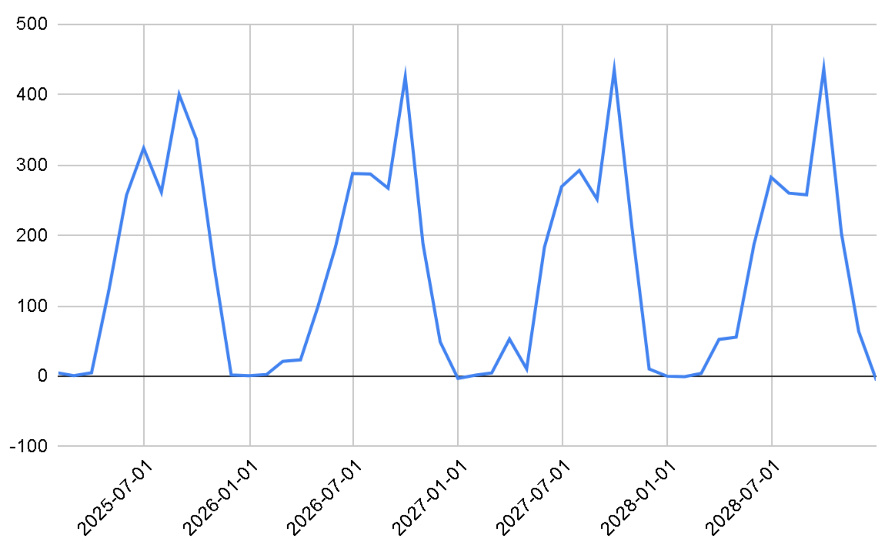

Figure 5: Rainfall Variation Graph

Figure 5 illustrates the cyclical pattern of rainfall fluctuations. The graph shows periodic increases in rainfall reaching peak levels, followed by declines approaching near-zero values in a recurring manner. This pattern may indicate seasonal rainfall cycles that occur consistently each year.

4. Discussion

The study of climate change in Kalasin Province using AI technology revealed continuous temperature increases, particularly in Quarters 2 and 4, influenced by global warming and El Niño phenomena. Rainfall demonstrated high variability, with declining trends in early year quarters and increased precipitation in later quarters, potentially linked to monsoon and tropical cyclone influences. These findings align with IPCC (2021) reports indicating global average temperature increases of approximately 1.09℃ since pre-industrial periods. The study provides clear evidence of climate change trends in Kalasin Province, with temperature projections showing increases of 1.79℃ in the first quarter and potentially up to 3.12℃ in the final quarter of 2028. The FAO's (2022) research on agricultural climate change impacts corroborates the study's findings of increased drought risks and rainfall uncertainty. The observed rainfall variability in Kalasin Province, with some years showing significant declines, reflects global trends of unpredictable precipitation patterns. The Meteorological Department's (2023) observations about the relationship between rainfall and meteorological phenomena like El Niño and La Niña are supported by this research, demonstrating the complex interactions influencing regional climate patterns.

5. Research Conclusions

This study aims to analyze the trends of temperature and rainfall changes in Kalasin Province using artificial intelligence (AI) technology for future weather forecasting and to compare the performance of different AI models in prediction. The findings indicate that the average temperature in Kalasin Province has shown a continuous upward trend from 2021 to 2024, with projections suggesting a further increase until 2028. The most significant rise is observed in the fourth quarter, reaching up to **3.12°C**. Regarding rainfall, high variability is evident, with certain periods experiencing a decline. For instance, in the first quarter of 2028, rainfall is expected to drop to **-0.38 mm**. However, some years, particularly in the third and fourth quarters, show an increase in rainfall, possibly influenced by **La Niña** and the **southwest monsoon**, which can intensify precipitation during certain periods. A comparison of AI model performance reveals that the **Long Short-Term Memory (LSTM)** model outperforms the **AutoRegressive Integrated Moving Average (ARIMA)** model in forecasting temperature and rainfall trends. LSTM demonstrates higher accuracy with a lower **Root Mean Square Error (RMSE)**, indicating its superior ability to capture long-term data patterns. However, the LSTM model still has certain limitations, particularly in handling rapid weather fluctuations observed toward the end of the year.

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