

**PEMODELAN SPASIAL SUHU PERMUKAAN LAHAN  
MENGUNAKAN ALGORITMA XGBOOST DAN *CELLULAR  
AUTOMATA-MARKOV CHAIN* DI KAWASAN PERKOTAAN  
YOGYAKARTA DAN SEKITARNYA TAHUN 1999-2029**

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**INTISARI**

Memanasnya temperatur permukaan semakin menunjukkan intensitas yang mengkhawatirkan. Anomali tersebut menyebabkan gletser dan salju di puncak tertinggi Indonesia menyusut drastis hingga Badan Meteorologi Klimatologi dan Geofisika (BMKG) mengangkat *headline* bertajuk Jelang Kepunahan Salju Abadi di Pegunungan Jayawijaya. Hal ini memantik pertanyaan; jika peningkatan temperatur global saat ini mampu menyasar dataran tinggi, lantas bagaimana nasib dataran rendah yang secara alami lebih panas? Penelitian ini bertujuan untuk mengetahui distribusi spasio-temporal suhu permukaan lahan (LST) di dataran rendah Kawasan Perkotaan Yogyakarta dan sekitarnya pada tahun 1999–2029.

Data historis LST tahun 1999–2024 pada musim kemarau (April–Oktober) diekstraksi dari *dataset* citra Landsat *Surface Reflectance* di Google Earth Engine menggunakan metode *Single-Channel*. Sementara data prediksi LST tahun 2029 diperoleh melalui pemodelan *machine learning* berbasis XGBoost di Google Colab. Fitur yang digunakan adalah data elevasi dan *slope* serta data penutup lahan dan indeks (NDVI, NDBI, dan NDMI) pada periode yang sama. Data penutup lahan tahun 2029 diperoleh dari pemodelan *Cellular Automata-Markov Chain*, sedangkan indeks tahun 2029 dari pemodelan XGBoost. Hasil seluruh pemodelan divisualisasikan dalam *web app* Streamlit berbasis Python.

Model prediksi LST berbasis XGBoost menghasilkan akurasi yang sangat baik dengan nilai  $R^2 > 0,96$  dan RMSE 0,7994 serta MAE 0,6162 (toleransi *error* prediksi LST  $\pm 2^\circ\text{C}$ ). Nilai LST diklasifikasikan ke dalam empat kelas, yaitu sangat rendah, rendah, sedang, dan tinggi. Pada tahun 1999–2009, kelas LST tinggi terpusat di Kota Yogyakarta dan Kapanewon Depok yang meluas ke kapanewon di sekitarnya mulai tahun 2014–2029. Kelas LST sangat rendah secara konsisten berada di Kapanewon Pakem, Turi, dan Cangkringan. Nilai rata-rata LST terendah di lokasi penelitian selama periode 1999–2029 adalah  $34,53^\circ\text{C}$  pada tahun 1999, sedangkan nilai LST tertinggi tercatat sebesar  $38,35^\circ\text{C}$  pada prediksi tahun 2029.

**Kata kunci:** Suhu Permukaan Lahan, Google Earth Engine, XGBoost, Prediksi, Analisis Spasio-temporal

***SPATIAL MODELING OF LAND SURFACE TEMPERATURE USING XGBOOST AND CELLULAR AUTOMATA-MARKOV CHAIN IN YOGYAKARTA URBAN AREA AND ITS SURROUNDINGS 1999–2029***

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**ABSTRACT**

*Global surface temperatures have been rising at a significant rate. This anomaly has caused glaciers and snow on Indonesia's highest peak to shrink drastically, to the extent that the Badan Meteorologi Klimatologi dan Geofisika (BMKG) issued a headline warning of Imminent Extinction of Eternal Snow in the Jayawijaya Mountains. This phenomenon raises a critical question; if global temperature increases can now affect high-altitude regions, what will become of lowland areas that area naturally warmer? This study aims to examine the spatio-temporal distribution of Land Surface Temperature (LST) in the lowland areas of Yogyakarta Urban Area and its surroundings from 1999 to 2029.*

*Historical LST data from 1999 to 2024 during the dry season (April–October) were extracted using the Single-Channel method from Landsat Surface Reflectance imagery datasets in Google Earth Engine. Meanwhile, LST predictions for 2029 were obtained through XGBoost machine learning modeling in Google Colab. The features utilized included elevation and slope data; land cover; NDVI, NDBI, and NDMI for the corresponding periods. Land cover for 2029 was derived from Cellular Automata-Markov Chain modelling, while the 2029 indices were generated through XGBoost modeling. All modeling results were visualized in a web application built on Python-based Streamlit.*

*The XGBoost-based LST prediction model demonstrated excellent accuracy with an  $R^2$  exceeding 0,96, along with an RMSE of 0,7994 and MAE of 0,6162 (prediction error tolerance of  $LST \pm 2^\circ\text{C}$ ). LST values were classified into four categories: very low, low, moderate, and high. From 1999 to 2009, high LST classes were concentrated in Yogyakarta City and Depok sub-district, expanding to surrounding sub-districts from 2014 to 2029. Very low LST classes were consistently located in Pakem, Turi, and Cangkringan sub-district. The lowest mean LST in the study area during the 1999–2029 period was  $34,53^\circ\text{C}$  in 1999, while the highest mean LST was recorded at  $38,35^\circ\text{C}$  in the 2029 prediction.*

**Keywords:** Land Surface Temperature, Google Earth Engine, XGBoost, Prediction, Spatio-temporal Analysis