# CHAPTER 1

# INTRODUCTION

## 1.1 Overview

Cultural heritage sites are the basis for our global and historical values. They connect us to the traditions left by our ancestors and contribute significantly to the cultural identity of human society (Lombardo et al., 2020). The preservation of cultural heritage, whether it be buildings or artifacts, is subject to various risks of damage and deterioration that result from microclimate conditions in the surrounding environment. These conditions are determined by several factors, including microclimate parameters such as temperature, humidity, airborne pollutants concentrations, air speed, and others (Fabbri & Bonora, 2021). Particularly in developing nations, these impacts pose a significant challenge to the preservation of cultural heritage (Pioppi et al., 2020). Safeguarding worldwide cultural heritage sites is of utmost importance for preserving cultural identity and human heritage, as well as promoting cultural and tourism-driven economic development (Alcaraz Tarragüel et al., 2012).

In recent years, the administration of cultural heritage sites and monuments has gained worldwide focus through the implementation of detection, monitoring, and comprehensive assessment methods. Initiatives are also underway to enhance and preserve these heritage resources by adopting suitable adaptation measures and sustainable management approaches (Guzman et al., 2020). To address these challenges, this thesis focuses on the application of advanced machine learning algorithms, namely Random Forest and XGBoost, for microclimate monitoring and prediction at cultural heritage sites. By leveraging these techniques, it aims to contribute to the preservation of cultural heritage sites under changing environmental conditions, ultimately supporting sustainable and efficient conservation efforts.

## 1.2 Problem Background

Cultural heritage sites have consistently drawn visitors who seek to spend quality time and pursue unique experiences by engaging with local cultures and communities (Ramkissoon et al., 2013). As a result, the economies of these tourist destinations largely rely on attracting visitors, encouraging repeat visits, garnering recommendations, and generating positive word-of-mouth regarding the locations (Rezapouraghdam et al., 2021). In addition, the natural environments in which tourism activities occur are also enhancing the well-being and quality of life for local residents (Ramkissoon et al., 2018). Lately, Johor Bahru has been experiencing frequent climate fluctuations that negatively impact the aesthetic appeal of the area's heritage sites, significantly affecting the industry of tourism and local economy. Generally, microclimate changes in these regions cause substantial damage to cultural heritage sites and various monuments. Consequently, striking a balance between consumption and conservation strategies presents increasing challenges for the effective management of cultural heritage sites (Buonincontri et al., 2017). Therefore, focusing on the preservation of cultural heritage and promoting sustainable tourism has become a primary objective recently to support both cultural heritage tourism and the overall well-being of communities (Megeirhi et al., 2020).

## 1.3 Research Aim

The goal of this study is to analyze vulnerable zones of cultural heritage (CH) sites and monuments in Johor Bahru, Malaysia, by employing microclimate monitoring and prediction through the Random Forest and XGBoost algorithms. By assessing temperature, humidity, and wind speed, the study aims to maintain environmental sustainability at these heritage sites. In this research, we have prepared a microclimate monitoring dashboard and evaluated the significance of factors contributing to microclimate changes. The Random Forest and XGBoost algorithms were employed to analyze the impact of these factors on the preservation of CH sites.

## 1.4 Research Objectives

The following are the objectives proposed:

(a) To investigate and identify the most suitable machine learning algorithms for analyzing microclimate data, and to recognize patterns, trends, and potential issues related to the heritage site's preservation.

(b) To evaluate the effectiveness of the developed machine learning models and the dashboard in assisting local authorities to plan preventive maintenance actions that preserve the site's aesthetics and cultural values.

(c) To develop and design a user-friendly dashboard that displays real-time microclimate data and provides recommendations for maintenance actions to assist local authorities with heritage site preservation.

## 1.5 Research Scopes

The scope of this research project covers several aspects related to the preservation of the Johor Bahru High Court and Sultan Ibrahim Building in Johor Bahru, using machine learning-based microclimate monitoring. The primary focus is on the development of a dashboard to collect, display, and analyze microclimate parameters for assisting the local authority in planning preventive maintenance actions for these two heritage sites. Specific areas included in the scope of this research are:

(a) Research involves obtaining microclimate data from the Malaysian Meteorological Department (MET Malaysia) for a designated heritage site in Johor Bahru. This data contains parameters like temperature, humidity, and wind speed.

(b) The research intends to compare the performance of two different machine learning algorithms between Random Forest and XGBoost to determine the most suitable method for microclimate monitoring and prediction.

(c) The project includes designing and developing an interactive user-friendly dashboard by using data visualization tools that display real-time microclimate data.

(d) The research will involve testing the effectiveness of the developed algorithm and dashboard in assisting local authorities with planning more effective maintenance plans for the heritage site.

## 1.6 Research Contribution

A thorough literature review on microclimate impacts on CH sites reveals that many researchers have used various statistical and machine learning methods, including Logistic Regression (LR), Artificial Neural Network (ANN), Convolutional Neural Network (CNN), K-Nearest Neighbor (KNN), and Support Vector Machine (SVM), to create microclimate monitoring and prediction dashboards. However, the combination of Random Forest and XGBoost algorithms, along with the analysis of temperature, humidity, and wind speed, has not yet been employed in the context of CH site preservation. As a result, this study offers a novel contribution to the machine learning field, particularly for modeling microclimate threats and risk assessments of cultural heritage sites.

In the context of the current changing climate and landscape, this study is highly relevant and makes a significant contribution to sustainable management of cultural heritage resources. Climate change can pose a significant threat to the integrity of heritage sites due to its impact on key environmental factors such as temperature, humidity, and wind patterns. This can lead to increased vulnerability and potential damage to these cultural assets. The study offers valuable insights and technical guidance regarding the selection of input causative factors, appropriate machine learning algorithms, and proper interpretation and evaluation of outcomes, which can inform future research and decision-making processes.

Moreover, this study has essential implications for the conservation of natural resources and heritage sites in Johor Bahru, Malaysia. The findings of this study are expected to have practical applications for professionals involved in land use planning,

landscape management, archaeological preservation, and public administration, as they strive to effectively manage cultural heritage sites and promote environmental sustainability through evidence-based strategies. By monitoring and predicting microclimate changes using Random Forest and XGBoost algorithms, stakeholders can better preserve and protect cultural heritage sites for future generations.

## 1.7 Report Organization

This report comprises five chapters. Chapter 1 introduces the topic of preserving cultural heritage sites through microclimate monitoring and prediction using Random Forest and XGBoost algorithms, the research background, and the purpose of conducting this study in Johor Bahru, Malaysia. Chapter 2 discusses the literature review related to microclimate monitoring, the assessment of temperature, humidity, and wind speed, as well as the comparison of machine learning techniques for processing and analyzing data from heritage sites. Chapter 3 delves into methodology of the research, describing how the study is conducted using the Random Forest and XGBoost algorithms to measure and analyze the data on temperature, humidity, and wind speed for preserving cultural heritage sites. Chapter 4 presents the research design and implementation, detailing how the experiment was executed to extract valuable insights from the microclimate data. Chapter 5 showcases the results obtained from this research, including the Power BI dashboard displaying the analyzed data. Finally, Chapter 6 offers a summary and conclusion for the study, highlighting the key findings and implications for the preservation of cultural heritage sites through microclimate monitoring and prediction using Random Forest and XGBoost algorithms.

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