Reducing Air Pollutants from Private Generators Using Digital Architecture to Enhance the Thermal Performance and Climate Response of Iraqi Buildings

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Abstract

Iraq is experiencing a serious environmental crisis affecting public health and the urban climate, characterized by a sharp rise in air pollution levels and the resulting respiratory illnesses. Studies show that the average concentration of fine particulate matter (PM2.5) in Iraq exceeds the World Health Organization's recommended limit by approximately 7-9 times (5 µg/m³). This pollution is attributed to several factors, most notably private generators, which citizens rely on due to frequent power outages in the national grid, particularly during peak summer periods when electricity demand increases to operate cooling systems. The increased strain on generators, which run on diesel or gasoline, leads to the emission of massive quantities of carbon dioxide and other pollutants, directly contributing to rising temperatures and environmental pollution in Iraqi cities. In this context, a significant portion of the increased electricity demand is attributed to shortcomings in the Architectural design process that neglect climatic considerations in Iraq. This leads to poor thermal performance in buildings, reduced insulation and heat retention capabilities, and an over-reliance on mechanical air conditioning systems. This research aims to integrate digital architectural technologies and artificial intelligence tools to assist architects in creating more climate-resilient buildings. This will be achieved through the development of a digital tool that generates architectural and environmental solutions and proposals based on the principles of sustainable passive design. The research also seeks to utilize virtual reality technologies and virtual environments to test the thermal and energy performance of designs under varying environmental conditions prior to implementation. The proposed research methodology relies on case studies of Iraqi buildings suffering from poor thermal efficiency and excessive reliance on cooling systems. These buildings will be modeled, simulated, and subjected to the application of sustainable design strategies, and their environmental and energy performance will be evaluated. This research is expected to improve the thermal efficiency of buildings, reduce loads on cooling systems, contribute to reducing carbon emissions from private generators, reduce the cost of electricity for Iraqi citizens, improve air quality, thus improving public health, and provide digital tools that shorten the path for architects to make effective design decisions in the early stages without the need to analyze the site before starting the design.