

From the Legacy of the World Cup to Serving Pilgrims:

A Joint Initiative by Qatar University and the Royal Commission for Makkah City and Holy Sites to Moderate the Climate at Jabal Al-Rahmah

On the plains of Mount Arafat, where millions of pilgrims gather to perform the central rite of Hajj, one of the most compelling examples of applying scientific knowledge in the service of humanity came to life during the 1447 AH Hajj season. Through a partnership between Qatar University and the Royal Commission for Makkah City and Holy Sites, engineering solutions were developed to moderate the climate in the courtyard of Jabal Al-Rahmah (Mount of Mercy). The initiative reflects the integration of research expertise and institutional collaboration in serving pilgrims at one

of the busiest and most significant sites of Hajj.

The initiative comes amid increasing climatic challenges during the pilgrimage season. Temperatures exceeded 45°C during peak daytime hours as millions of pilgrims from around the world gathered on the plains of Arafat to perform the most important rite of Hajj. In line with the commitment of the Government of the Custodian of the Two Holy Mosques to provide pilgrims with a safe and healthy environment, extensive efforts and resources were mobilized, while innovative solutions were adopted to enhance the quality of services offered during Hajj.

At the heart of this initiative stands Professor Saud Abdul-Ghani, Professor of Mechanical Engineering at Qatar University, whose name became internationally associated with the development of open-space stadium cooling technologies that attracted global attention during the FIFA World Cup Qatar 2022™. Professor Abdul-Ghani led the design efforts and supervised the implementation of the project's initial phase, drawing upon years of accumulated research experience in aerodynamics, computational modelling, and the control of open thermal environments.

During the World Cup, Qatar presented an exceptional model for hosting major events, not only through efficient organization and crowd management, but also through the development of innovative cooling technologies capable of regulating open thermal environments under challenging climatic conditions. The impact of these innovations extended well beyond stadiums, finding new applications that serve humanity in diverse contexts. Today, one of their most meaningful manifestations can be found in the service of pilgrims.

The project team employed advanced computational modelling to understand the thermal characteristics of Jabal Al-Rahmah and its surrounding courtyards, which cover an estimated area of 62,000 square meters. The analyses revealed that the mountain's rocky mass and the surrounding sun-exposed areas function as a thermal reservoir, absorbing solar energy, storing it, and subsequently re-radiating it into the environment, thereby intensifying heat exposure among densely gathered crowds.

Based on these findings, a phased heat-stress mitigation system was developed, integrating climate moderation measures with crowd management requirements. The initial phase included the deployment of oscillating misting fans and the installation of large umbrellas around parts of the mountain's perimeter to provide shade and reduce direct exposure to solar radiation.

The pilot phase subsequently evolved to incorporate seven cooling stations distributed across the Jabal Al-Rahmah area, with a total cooling capacity of approximately 3,500 refrigeration tons. Chilled air is delivered through an underground network of massive pipes, some measuring up to two meters in diameter, before being distributed through ground-level outlets and specially designed columns to regulate the microclimate in the central courtyard, thereby improving thermal comfort and alleviating the effects of heat stress associated with extreme temperatures.

This initiative demonstrates how regional research partnerships can transform knowledge into tangible impact and translate innovation from the realm of sporting achievement into humanitarian service. In the Holy Sites, Qatar's engineering legacy has acquired a new human dimension, where technological ingenuity meets a spirit of service. In doing so, scientific research becomes a means of protecting people, enhancing their well-being, and improving their experience of performing sacred rituals, reflecting the noblest purpose of science when dedicated to the service of communities.