

Supplementary File 1. Selection of review materials



Figure SF1. The selection of review samples.

The review sample selection process is illustrated in Figure SF1. Scopus and Web of Science were chosen as the primary search databases due to their comprehensive and reliable coverage of academic literature. The initial search query targeted records containing the terms ‘climate change,’ and ‘urban digital twin’ or ‘digital twin’ within the title, abstract, or keywords. This search, conducted in February 2025, returned a total of 531 results.

A series of filtering steps followed. Duplicates were removed, and results were limited to English-language publications, focusing solely on peer-reviewed journal articles and review papers. Full-text screening was then conducted to exclude studies that did not focus on critical infrastructure. Additionally, articles that referenced

the term “Digital Twin” but lacked key DT characteristics, such as real-time data integration, bi-directional connectivity, or system-level modelling, were also excluded.

To strengthen the conceptual coverage of the review, several seminal studies addressing the complexity of urban infrastructure systems within the smart city context were manually added. Furthermore, selected non-academic materials were incorporated to capture practical advancements in the field. In total, 68 publications were selected for final review.