

# **Spatiotemporal Analysis of Urban Transformation in Hanoi, Vietnam**

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Hanoi City, the capital of Vietnam, is one of the fastest-growing cities in Southeast Asia. However, there were many lakes and ponds which were relict lakes of Red River in Hanoi City before the 19th century. In the early 20th century, they had disappeared almost completely on the map. There are two important key points when we think this urban transformation in Hanoi City. One is that Vietnam was under the French rule in the late 19th century. An urban planning of French government had a profound influence on an urban development of Hanoi City. The other is the geography of Hanoi City and natural environment around it. Hanoi City is located in a flood plain of Red River, the average elevation being less than 10 meters. It has been facing the repeated flood for long time. According to the map which was drawn by French government, there was already a large-scale dike in the late 19th century. Therefore, it is important to consider the topographical changes in Hanoi City. Analyzing the relief of terrain and micro-topography of Hanoi City plays an important role towards an explanation of urban transformation. It is necessary to generate the DEM (Digital Elevation Model) using the elevation data to analyze the topographical changes. DEM is a digital representation of ground surface and the most important element of topographical analysis for urban transformation (i.e. evidence of existence such as old rivers, lakes, fills and land subsidence). Consequently, the DEM of Hanoi City in 2005 was generated by the collected 8,015 points data. Based on the surface estimation method using Cubic B-Spline Function, it is generated at 2 meter resolution. Contour interval is 0.5 meter. The very subtle elevation gaps which can not be distinguished on the satellite image are significantly recognizable on this DEM. Meanwhile, the topographical map as a paper map was generated by French government in 1950 which belongs to French library. The DEM at 2 meter resolution also is based on the DEM generation using the method of STRIPE. It enables to show the differences between DEM 2005 and 1950. By comparing 2 patterns of DEM spatiotemporally, the area of fills and land subsidence are figured out. It must be useful for studying an urban transformation because it is difficult to estimate how so many lakes and ponds disappeared by using only 2D or 3D spatial analysis.