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Spatial Analysis of Terrorism Vulnerability – A Case Study of Tokyo, Japan

テロリズムに対する脆弱性の空間分析 ― 東京都都心を事例として

Motivation – 動機

A lot of research has been performed on the topic of terrorism risk assessment from financial, sociological, and also spatial perspectives. Yet, risk-based terrorism analysis revealed several shortcomings, such as a lack of spatially explicit data of past events. Also, risk-based analysis can only elaborate reactively on events that have either occurred in the past, or are the outcome of simulated models.

Originality – 新規性

This fact can be ameliorated by employing a proactive bottom-up approach based on vulnerability (脆弱性) instead of risk. While the latter is the active aspect of any threat, the former can be perceived as a passive attribute of the objects or people at risk. Hence vulnerability analysis focuses on the geography instead of the event. Thereby spatial terrorism vulnerability analysis can be understood as a methodology to evaluate possible targets on a micro scale, in the case of the case study presented in this paper on building level within a study area in the Tokyo Metropolitan Area. We postulate that vulnerability is not distributed equally in space, and that attributes of objects can be identified that affect their vulnerability, both positively and negatively.

Approach – 方法

In our research framework vulnerability is based on two components: susceptibility (敏感性), i.e. factors and attributes that make an asset more or less susceptible to become the target of a terrorist attack, and disutility (不効用性), which describes the value (worth) of the consequences a successful attack has to the stakeholders. This paper focuses exclusively on the susceptibility component.

As a first step, factors were identified that contribute to the susceptibility of buildings to terrorist attacks. For the case study presented in this paper, the *number of people in a building* (BP), the *volume of public traffic* both inside and outside (PT), the existence of (public) underground *parking garages* (PG), as well as the *symbolic value* (SV) were selected, as they have the potential to make one building more attractive to an attack than others. In order to be used together in a numeric analysis framework, these factors were operationalized and transformed to normalized nominal scales as a next step.

Our analysis focused on the effect that the susceptibility factors have on the object's surroundings, i.e. their spatial influence (SI; 空間的な影響). Generally we were using two types of operationalization for this spatial influence, one being *spatial proximity* (空間的近接) to account for the fact that each object affects the space surrounding itself by its attributes, the other one being *spatial concentration* (空間的集中) to identify hotspots, i.e. spatial agglomerations of similar attributes.

Results – 結果

For each of those susceptibility factors, factor maps were generated, which were then combined into an overall susceptibility map using map algebra (i.e. raster combinations). In this process it is also possible to assign different weights to the single factor maps to raise or lower the importance of the corresponding factor (Fig. 2). Once this was done, **vulnerability maps** for all attack scenarios of interest were calculated and, together with a terrorism **disutility map**, combined into one micro-scale multi-threat terrorism **vulnerability map** (Fig. 1).

This map can be useful both to raise awareness for and easily communicate the concept of terrorism vulnerability to the public, and to assist stakeholders (e.g. police, government, city planners, building owners) in identifying areas that are in need of action towards mitigation against becoming target of a terrorist attack.

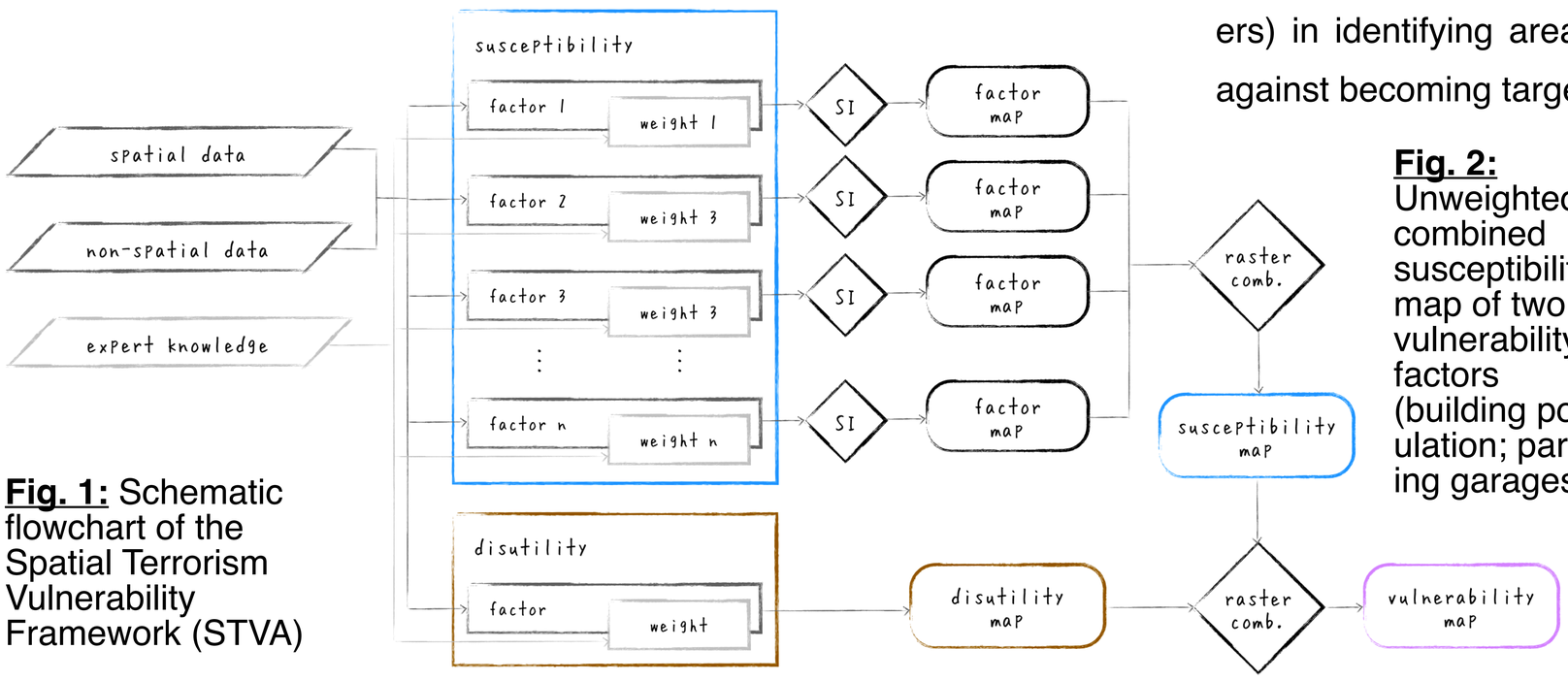

Fig. 1: Schematic flowchart of the Spatial Terrorism Vulnerability Framework (STVA)

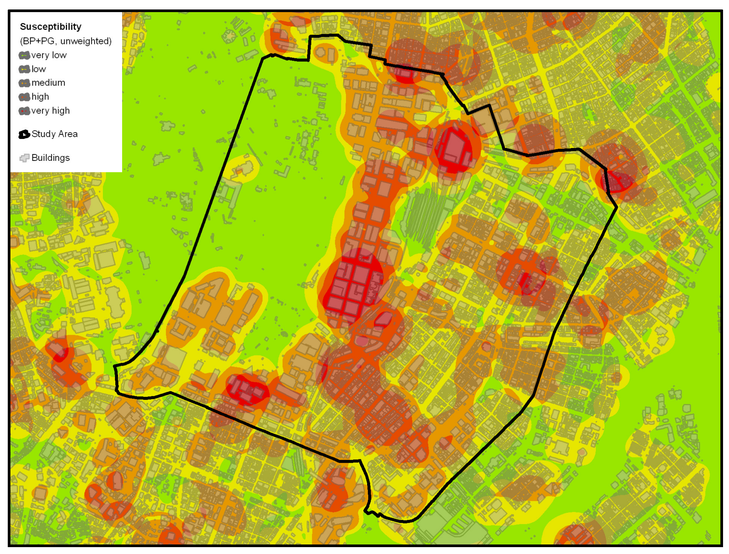

Fig. 2: Unweighted combined susceptibility map of two vulnerability factors (building population; parking garages)