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Presentation title: Analyzing Causal Loop Diagrams through the graph theory framework to identify key leverage points for sustainability in urban-rural systems in northeastern Illinois (USA)

Complex problems are often challenging to solve. System science methods help to unwrap these complexities and provide enough clarity to identify the processes, logic, and dynamics of the complex systems. These methods are specifically well-suited for sustainability-related topics (Ford 1999) in urban (Zellner et al. 2008) and rural (Jamshed et al. 2020) environments. Food-energy-water (FEW) nexus is a good example. It is a part of a global sustainable agenda that means that the three domains – food security, energy security, and water security – are indissolubly linked. Community engagement and expert participation are essential to collect a broad view of problem complexity from different perspectives. Therefore, we created Causal Loop Diagrams (CLD) to visually represent FEW interrelations based on the results of the participatory modeling process based on workshops with external experts where the focus was made on the urban-rural connections in northeastern Illinois (USA). After that, the main aim of our research was to determine leverage points of the FEW system by quantifying the importance of the elements in our CLD. The structure of CLD is similar to a graph, so we represented it as a directed graph. The topology of a graph regulates an influence structure between vertices and, as a result, the entire system's behavior. We used known measures from graph theory (Özesmi and Özesmi 2004; Freeman 1978) to identify and provide information on vertex importance in the system. These common measures are network density, average path length, modularity, degree, closeness, betweenness, eigenvector, and PageRank. All the above measures focus on each vertex within the graph with relation to their neighbors, however, they do not take into account the loop-based structure of the system, which we found to be very important to describe the system. To address this issue, we developed a tool that can conduct this analysis and compare results with other conventional measures. As a result, we identified the most critical variables in the FEW system, which are strongly related to the climate activism in local areas, commodity and non-commodity food production, legislature support for climate change policies, and political will on both local and regional levels.

Keywords: graph theory, causal loop diagrams, complex systems, sustainability, climate change mitigation

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Presentation title: A Study on the Adaptive Competency and Spatial Distribution of Vulnerable Groups in Heatwave Vulnerable Areas from the perspective of Environmental Justice

The impact of climate change has a particularly greater impact on the socially vulnerable, and the UN's Human Development Report (UNDP, 2015) is concerned that climate change will have a significant impact in the long run, especially the sensitive class. In addition, for the establishment and research of national climate change policies, an understanding of climate change vulnerabilities in a country must be made. However, since there is a lack of spatial empirical analysis studies on the interrelationship between the heatwave and the socially vulnerable, this study first set the range from 2010 to 2018 in terms of time, and conducted the study at the national city, county, and district level in terms of spatial scope. This study focused primarily on heat waves and socially vulnerable groups for environmental justice, and based on the IPCC's climate change vulnerability assessment concept, deduced areas vulnerable to heatwaves and densely populated areas of socially vulnerable groups by city, county, and gu(district) in Korea. In addition, the purpose of this study was to conduct basic research to improve the ability to adapt to the heat wave in the future and to find a continuous disaster prevention plan in the city by identifying regions with relatively low ability to adapt to heat waves through spatial regression. It was found that the spatial autocorrelation of the dependent variables related to heatwave damage, average surface temperature, heatwave days, and maximum temperature was high. 1) Areas with high average surface temperature and overlapping areas of basic recipients: Jeollabuk-do, Gyeongsangbuk-do, Daejeon Metropolitan City, Gwangju Metropolitan City 2) Areas with the longest number of heatwave days and areas overlapping with areas with dense population over 65: Daegu Metropolitan City, Gyeongsangbuk-do, and Gyeongsangnamdo tended to be high. Accordingly, it is judged that policies and strategies such as heat shelters for basic recipients due to heat waves are needed in the above 1) areas, and 2) policies to respond to heatwaves are needed. It was found that a relatively large number of economically vulnerable groups were distributed in regions where heat waves occur, and it was confirmed that environmental injustice existed. This suggests that it is necessary to urgently solve the heatwave problem from the perspective of climate justice, and to consider social measures in addition to physical heatwave measures.

Keywords: Climate change, heat wave, socially vulnerable group, heat wave vulnerability, resilience, climate justice

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Presentation title: A Digital Curation of Vulnerability to Flood Fatalities in Harris County, TX

Globally, flooding is the most common form of disaster related deaths. The phenomenon of driver related fatalities during extreme flooding is a universal issue among nations dependent on automobiles (Vinet, Boissier, & Saint-Martin, 2016; Haynes, et al., 2016; Peden et al., 2017). Half of these occur when driving through flooded streets (Ashley & Ashley, 2008). From 1959 – 2009, Texas has annually led the United States in the number of flood fatalities (Sharif et al, 2012). Texas has experienced a dramatic increase in vehicle-related deaths during flooding events since the 1990s (Maples & Tiefenbacher, 2009). Houston, Texas, county seat of Harris County is the fourth largest city in the United States, and has a history of flooding, continued population explosion, and increasing built environment. This research asks the question what people and places are vulnerable to vehicle related flood fatalities in Harris County, TX? This research conducted street observations, interviewed survivors of driving in floods, and determined those that had died during five extreme rain events in Harris County from 2000-2020. By incorporating digital archives, this research created a 3-dimensional database for locations and people involved in vehicle related fatalities. The digital curation allowed for a deeper qualitative analysis of groups and locations vulnerable to flooding fatalities (Davey & Benjaminsen, 2021). This research resulted in a final product that includes the victims demographics, reasons for driving, and street design characteristics at the fatality locations. All fatalities that occurred in Harris County were story mapped through ArcGIS with digital videos curated and created to provide a transformative research tool which includes the narratives of vulnerable populations. This research concludes that low income and marginalized groups are most vulnerable, and road design error does contribute to fatalities. As climate change increases the frequency and intensity of storms, climate justice and transportation policymakers alike can benefit from these findings and should incorporate them in mitigation strategies.

Keywords: Flooding, Transportation, Digital Curation, Vulnerable Populations, Fatalities

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