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# Spatial Modeling of Disaster Resilience in the Lower Mississippi River Basin

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**Abstract:**

The Lower Mississippi River Basin (LMRB) in southeastern Louisiana is one of the most impacted and vulnerable coasts in the continental USA. This area has been facing recurring threats from coastal hazards in a long run. These hazardous events have negatively impacted the communities in various degrees. Therefore, identifying the places that are resilient to disasters and understanding the dynamic interactions among indicators are critical topics for pre-disaster preparation, post-disaster recovery, and establishment of mitigation plans.

Studies on how variables of community resilience to natural hazards interact as a system that affects the final resilience (i.e., their dynamical linkages) have rarely been conducted. Bayesian network (BN), which represents the interdependencies among variables in a graph while expressing the uncertainty in the form of probability distributions, offers an effective way to investigate the interactions among different resilience components and addresses the natural–human system as a whole. This study employed a BN to study the interdependencies of ten resilience variables and population change in the Lower Mississippi River Basin (LMRB) at the census block group scale. A genetic algorithm was used to identify an optimal BN where population change, a cumulative resilience indicator, was the target variable. The results uncovered a set of important resilience variables that could account for the spatial variation of population changes in a region vulnerable to coastal hazards, also identify and quantify the interactions among these variables in a probabilistic form, the results of which can then be used for future scenario modeling and planning for resilience.

Specifically, an optimal Bayesian network model was developed to explain the population change dynamics using data at block group scale. The study first extracted 10 variables from a group of 35 to derive the network. Through a genetic algorithm and after 906 generations, the resultant optimized Bayesian network was achieved with a cross-validation accuracy of 67%. The expectation-maximization (EM) method was used to learn the conditional probability tables, and the junction tree (JT) algorithm was applied to compute the posterior probabilities. Six variables were found to have direct impacts on population change, including hazard exposure, hazard damages, distance to coastline, employment rate, percent housing units built before 1970, and percent households with female householder. The remaining four variables are indirect variables, including percent agriculture land, percent flood zone area, percent owner-occupied housing units, and population density. Each variable has a conditional probability table so that its impacts on the probability of population change can be evaluated as it propagates through the network. These probabilities could be used for scenario modeling in the subsequent studies to help inform policies to reduce vulnerability and enhance resilience.

We further used the developed BN model to simulate the probability of percent of population change under different scenarios by varying the probability distributions of some input variables. The simulation process was carried out through computing the posterior probability of the target variable. Findings from the scenarios simulation offer useful information on how the factors interact that lead to population change, which can be used to inform decision making on disaster resilience and adaptation strategies.

For example, the scenarios of lowering either the hazard exposure or damages (Scenarios 1 and 2) reveal a spatial pattern of which population-change state 4 (-5.5% to 34.4%) becomes dominant, whereas extreme increase and decrease are less probable. Findings from Scenario 3 show that without the hazard exposure and damages the spatial pattern shows that no extreme population increase or decrease would possibly happen under the current socioeconomic and environmental condition. Results also show that reducing the percentage of housing units built before 1970 would be more effective than increasing the employment rate in terms of reducing population loss.