Assessing Property Loss in Louisiana, U.S.A., to Natural Hazards Incorporating Future Projected Conditions

Rubayet Bin Mostafiz[1], Carol Friedland[1], Robert Rohli[1], and Nazla Bushra[1]

[1]Louisiana State University

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Abstract

Proper assessment of the economic risk from hazards is an important prerequisite toward enhancing resilience and is often overlooked or underestimated in importance. This research describes a method of assessing risk due to extreme cold temperature, hail, lightning, and tornado in 2050, utilizing projections from well-respected model output, with Louisiana as a case study. Our approach improves upon previous hazard risk assessments by considering the magnitude of the exposed population in weighing the property loss. This makes the approach her preferable over previous risk assessments. Furthermore, the present research uses current model projections to estimate changes in future conditions of the hazard presence. Finally, our use of downscaled data to the census-block circumvents the complications of examining hazards at the county level, particularly in cases for which population is unevenly distributed in the county. Results suggest that extreme cold temperature and tornado are by far the costliest of the four hazards in terms of property loss, although tornado loss is inherently difficult to project due to the unpredictable nature of individual tornado paths. Both extreme temperatures and hail are projected to decrease in loss as temperatures warm, especially in the New Orleans area, where population may decrease. The lightning hazard, while small and likely underestimated due to assignment of lightning damage to the phenomena in which it is embedded, is projected to increase, both on an absolute and per capita basis. Our results can assist environmental planners in protecting life and property, while also promoting hazard resilience and environmental, economic, and social sustainability.

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Rubayet Bin Mostafiz[1], Carol J. Friedland[2], Robert V. Rohli[1] , Nazla Bushra[1]

[1] Department of Oceanography & Coastal Sciences, Louisiana State University, Baton Rouge, LA, USA 70803–4105; rbinmo1@lsu.edu, rohli@lsu.edu, nbushr1@lsu.edu

[2] Bert S. Turner Department of Construction Management, Louisiana State University, Baton Rouge, LA, USA 70803–4105; friedland@lsu.edu

ABSTRACT

Proper assessment of the economic risk from hazards is an important prerequisite toward enhancing resilience and is often overlooked or underestimated in importance. This research describes a method of assessing risk due to extreme cold temperature, hail, lightning, and tornado in 2050, utilizing projections from well-respected model output, with Louisiana as a case study. Our approach improves upon previous hazard risk assessments by considering the magnitude of the exposed population in weighing the property loss. This makes the approach her preferable over previous risk assessments. Furthermore, the present research uses current model projections to estimate changes in future conditions of the hazard presence. Finally, our use of downscaled data to the census-block circumvents the complications of examining hazards at the county level, particularly in cases for which population is unevenly distributed in the county. Results suggest that extreme cold temperature and tornado are by far the costliest of the four hazards in terms of property loss, although tornado loss is inherently difficult to project due to the unpredictable nature of individual tornado paths. Both extreme temperatures and hail are projected to decrease in loss as temperatures warm, especially in the New Orleans area, where population may decrease. The lightning hazard, while small and likely underestimated due to assignment of lightning damage to the phenomena in which it is embedded, is projected to increase, both on an absolute and per capita basis. Our results can assist environmental planners in protecting life and property, while also promoting hazard resilience and environmental, economic, and social sustainability.

INTRODUCTION

Louisiana is an example of a vulnerable coastal environment where risk assessment is an important endeavor. Thirteen tropical cyclones that have affected Louisiana since 2000 have each caused over $1 billion in damage (National Centers for Environmental Information (NCEI, formerly known as the National Climatic Data Center (NCDC)) 2020). Other events, most notably the August 2016 floods, have added to the list of federally declared disasters. In addition, coastal Louisiana is affected by insidious hazards that may potentially cause catastrophic loss, such as eustatic sea level rise with its attendant increased vulnerability to salt water intrusion and storm surge, and levee and dam failure, in addition to those that are common in adjacent inland areas, such as lightning, thunderstorms, hail, tornadoes, drought, wildfire, and winter storms. The hazards selected for analysis are those that appear in the 2014 and 2019 updates of the Louisiana State Hazard Mitigation Plan (SHMP) and produce widespread losses statewide; they include extreme cold temperature, hail, lightning, and tornadoes.

DATA

Table 1. Years analyzed, data sources and projected change by 2050, by hazard in Louisiana.

Hazard	Years of Data Analyzed	Intensity Metric	Data Source	Projected Change by 2050
Extreme Cold	1992–2017	Annual frequency of days with temperatures < 32°F	National Centers for Environmental Information (NCEI)	−20% days under 32° F
Hail	1982–2011	Hail days per year	National Severe Storms Laboratory (NSSL)	−10% days with hail
Lightning	1986–2012	Lightning density per year	NCEI	+10% increase in flash intensity
Tornado	1950–2016	Tornado days per year	Storm Prediction Center (SPC)	+10% probability of occurrence

Historical property loss data for extreme cold temperature, hail, lightning, and tornado hazards were retrieved from the Spatial Hazards Events and Losses Database for the United States (SHELDUS^{TM}) produced by the Center for Emergency Management and Homeland Security (CEMHS 2017). The parish-level (analogous to county-level in other U.S. states) loss data covered the time period from 1960 through 2016 and were adjusted by inflation to 2016 dollars (2016$). Table 1 shows details of the years of analysis by hazard, along with the data source. Future projection of hazards relied on information from the fourth National Climate Assessment (NCA4; U.S. Global Change Research Program 2017) and population projections were based on data from U.S. Census Bureau (2020).

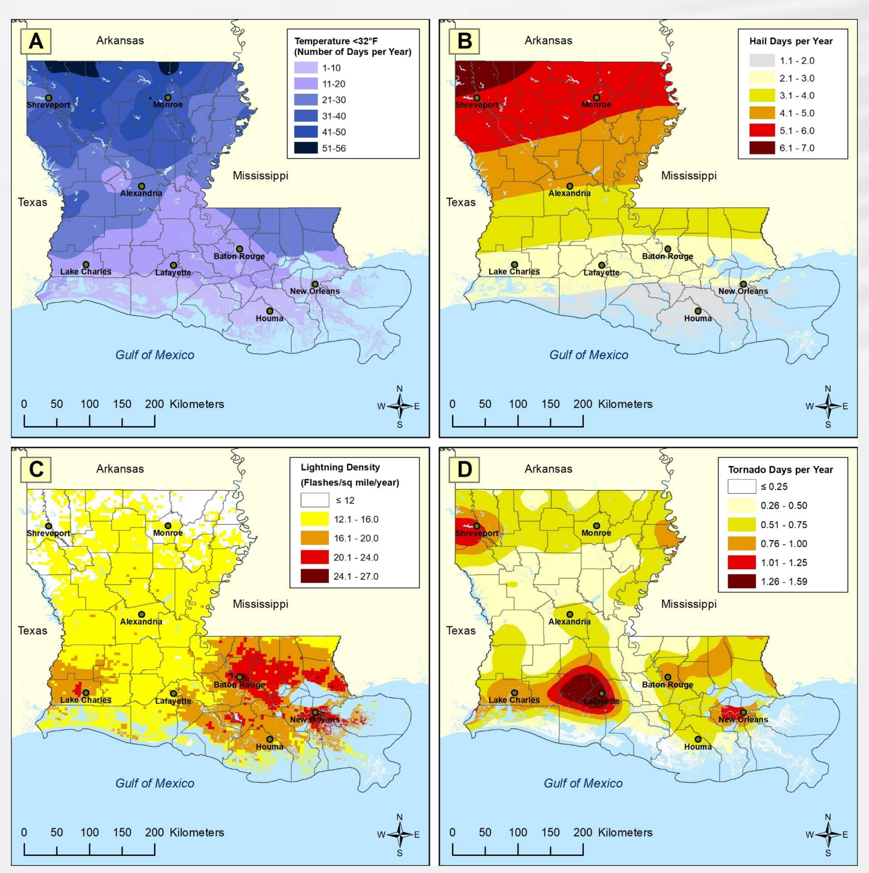

Figure 1| Historical average hazard intensity in Louisiana: extreme cold temperature (A), hail (B), lightning (C), and tornado (D).

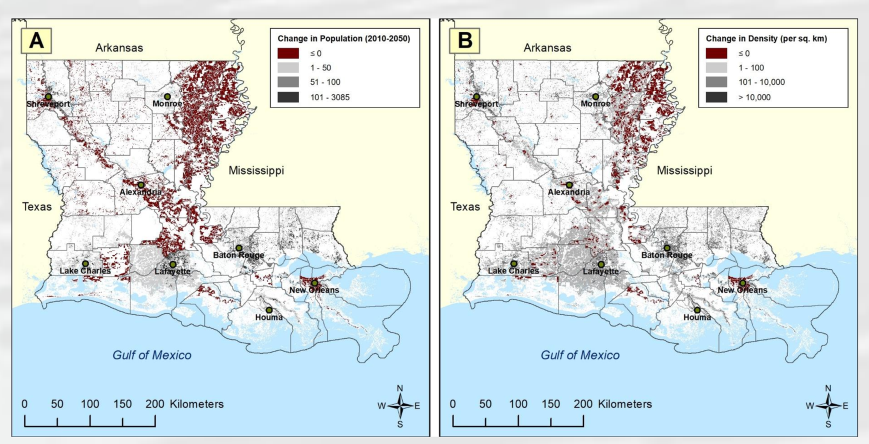

Figure 2: Change in population (A) and density (B) by census block in Louisiana from 2010 to projection for 2050.

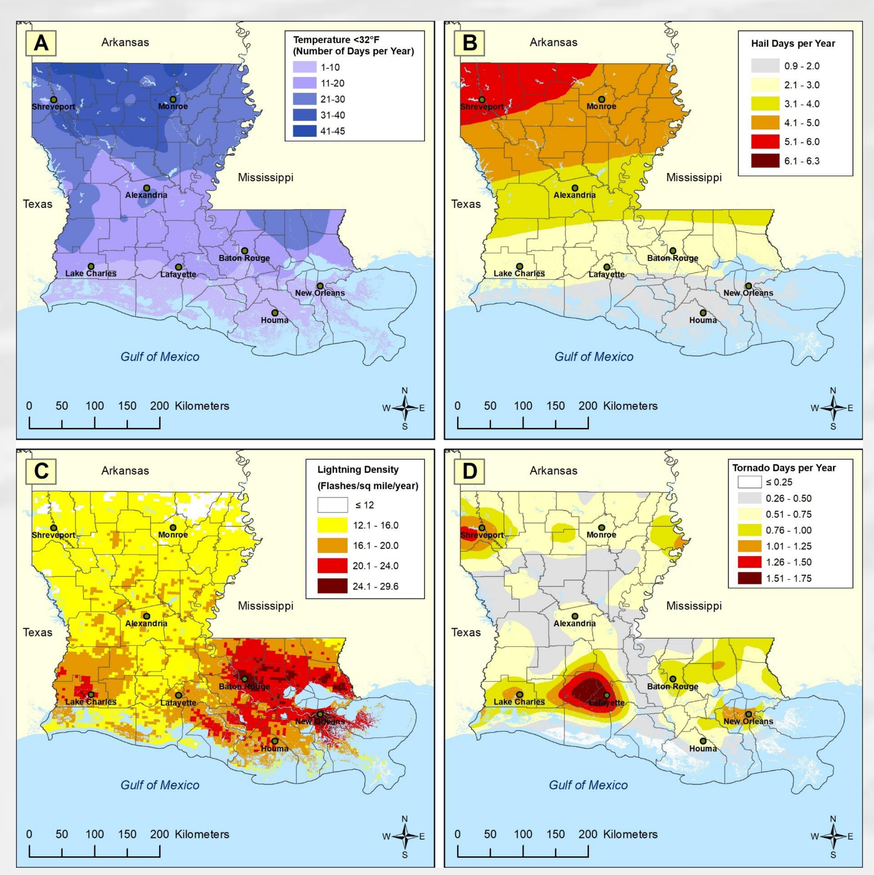

Figure 3: As in Figure 1, but projected for 2050.

METHODS

Population Projection

Historical annual population estimates from the U.S. Census Bureau (2020) were used to generate future census-block level population estimates for the year 2050. For each parish i, parish-level overall average rate (ri) of population change was calculated as the average of annual relative parish-level population changes from the previous year for the n-year period of consideration beginning in year y. Here, the 38-year period from 1980 to 2018 was considered (Equation 1).

$$r_i = \frac{\sum_{y}^{y+n}\left[\frac{\left(P_{i,y+1} - P_{i,y}\right)}{P_{i,y}}\right]}{n} \qquad (1)$$

After ri was determined for each parish, future population change was downscaled to the census-block level (j), and projected for each census block, given the assumptions that 1) population change is confined to currently inhabited census blocks and 2) the overall average rate of population change is constant for all census blocks within the parish. Using 2010 census-block-level U.S. Census population data as the initial population basis (P0=P2010) future population for each census block j (P(f,j)=P(2050,j)) given a 40-year period (t).within the census block changes; while at the census-block level were calculated for 2050, assuming a continuous growth curve (Equation 2).

$$P_{f,j} = P_{0,j}\, e^{r_i t} \qquad (2)$$

Method for Assessing Future Hazard Intensity:

Future average annual hazard intensity predicted in each census block j for each hazard k, (H(f,j,k)) are determined by scaling historical hazard intensities H(j,k) with the statewide adjustment coefficients A(f,k) (Equation 3).

$$H_{f,j,k} = H_{j,k} \times A_{f,k} \qquad (3)$$

Method of Quantifying Historical per Capita Property Loss

For each hazard k, parish-level (i) mean annual per capita property loss (C(i,k)) was calculated by averaging historical annual per capita property loss (2016$) within SHELDUS for the 57-year period (1960–2016), as shown in Equation 4.

$$\overline{C_{i,k}} = \frac{\left[C_{i,k,1960} + C_{i,k,1961} + C_{i,k,1962} + \cdots + C_{i,k,2015} + C_{i,k,2016}\right]}{57} \qquad (4)$$

Method of Projecting Future Property Loss

Baseline average annual parish(i)-level loss for each hazard k (L(0,i,k); Equation 5) is calculated as the product of the historical parish-level mean annual per capita loss (C(i,k)) and the total parish population, represented as the summation of the baseline census block population P(0,j) for ji=1 to Ji, representing the total number of census blocks in parish i. The 2010 population was used for the analysis.

$$L_{0,i,k} = \overline{C_{i,k}} \sum_{j_i=1}^{J_i} P_{0,j_i} \qquad (5)$$

Baseline parish-level hazard- and population-adjusted loss ratio LR(0,i,k) is then calculated by dividing the baseline average annual parish-level loss into increments reflecting the product of historical hazard intensity H(j,k) and baseline census block population (Equation 6).

$$LR_{0,i,k} = \frac{L_{0,i,k}}{\sum_{j=1}^{n}\left(H_{j,k} \times P_{0,j}\right)} \qquad (6)$$

To achieve an estimate of future property loss at the census block level for each hazard k (L(f,j,k); Equation 7) the parish-level hazard- and population-adjusted loss ratio is then applied to the future average annual hazard intensity (H(f,j,k); from Equation 3) and population (P(f,j); from Equation 2) within the census block.

$$L_{f,j,k} = LR_{0,i,k} \times H_{f,j,k} \times P_{f,j} \qquad (7)$$

RESULTS AND DISCUSSION

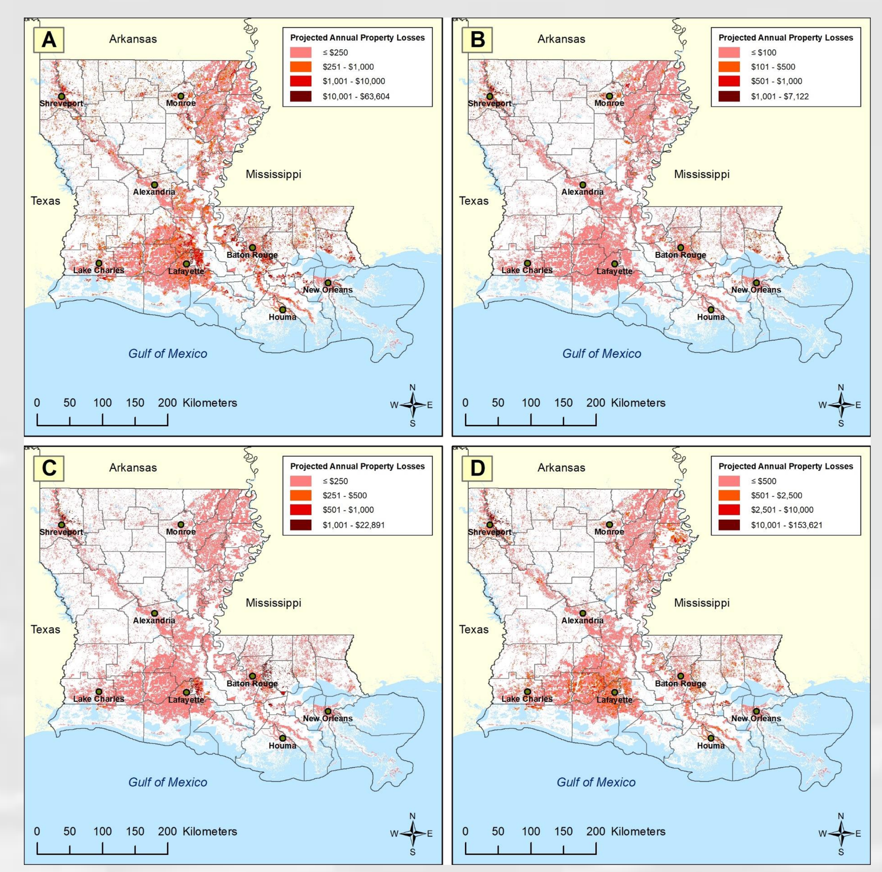

Figure 4: Projected annual property loss (2016$) by census block in Louisiana, 2050: Extreme cold temperatures (A); hail (B); lightning (C); and tornado (D).

On a statewide basis, of the four hazards analyzed here, the vast majority (89.1 percent) of historical average annual property losses occurred because of extreme cold temperatures and tornadoes (Table 2).

Table 2: Comparison of Louisiana's property loss, by hazard: Historical vs. 2050-projected.

Hazard	Average Annual Property Loss 1960–2016 (2016$)	Projected Annual Property Loss in 2050 (2016$)	Projected Change (%)
Extreme Cold	$12,555,208	$23,222,951	84.97%
Hail	$1,574,961	$2,488,456	58.00%
Lightning	$1,701,016	$4,311,374	153.46%
Tornado	$14,317,682	$24,344,292	70.03%
Total	$30,148,867	$54,367,073	80.33%

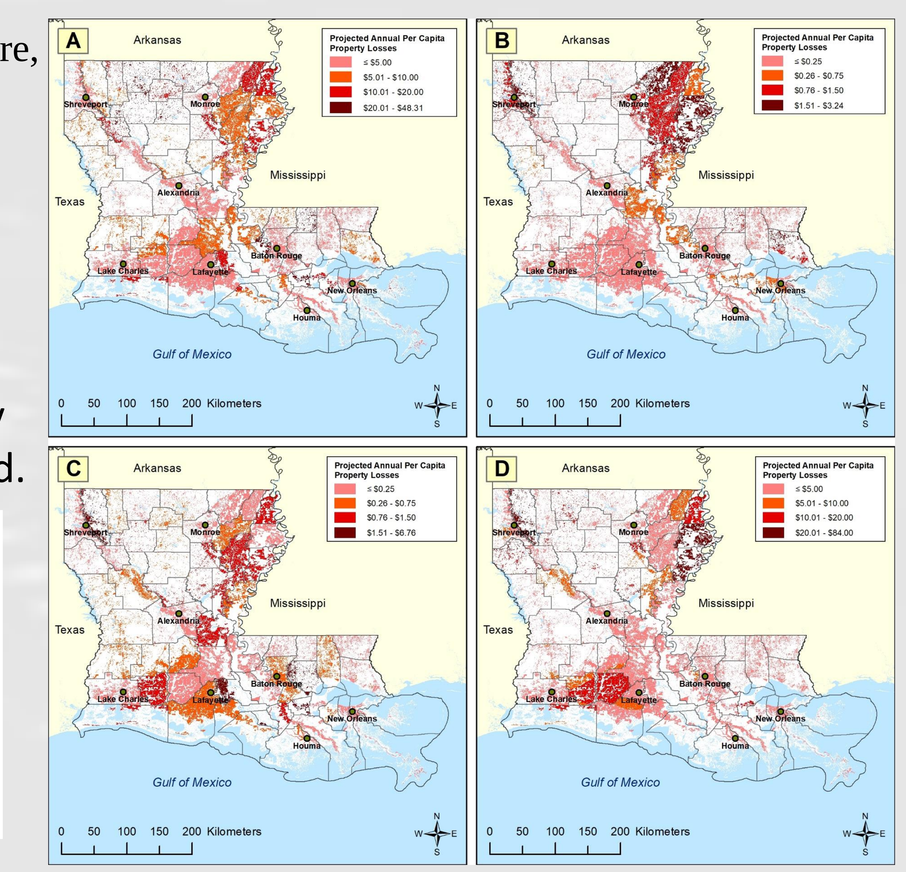

Figure 5: Projected annual per capita property loss (2016$) by census block in Louisiana, 2050: Extreme cold temperatures (A); hail (B); lightning (C); and tornado (D).

Both present and future losses to the four hazards are generally concentrated in the heavily-populated parts of Louisiana, but with some modifications due to spatial variability in historical and projected hazard intensities. For Louisiana as a whole, extreme cold temperature and tornado are by far the costliest of the four hazards in terms of property loss, although tornado loss is inherently difficult to project due to the unpredictable nature of individual tornado paths. Both extreme temperatures and hail are projected to decrease in loss as temperatures warm, especially in the New Orleans area, where population may decrease. The lightning hazard, while small and likely underestimated due to assignment of lightning damage to the phenomena in which it is embedded, is projected to increase, both on an absolute and per capita basis. These results are important because they will guide environmental planners as they allocate resources for mitigating and adapting to these natural hazards in one of the most weather-hazard-vulnerable states in the U.S.A.

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