Mapping Vulnerability of Farming Communities to Winter Storms in Iowa

Yiyi Zhang[1] and Bingqing Liang[1]

[1]University of Northern Iowa

November 22, 2022

Abstract

Driven by unusually warm air in the Arctic, severe winter weather moves down south to mid-latitude areas, reflecting the complexity in the ways that climate change may affect local weather extremes. Food and agriculture have been identified as central to global efforts to adapt to climate change. However, research is notably lacking in understanding the vulnerability of farming communities to winter storms that are recognized as one of catastrophic events leading to agricultural damage and loss. This study focuses on mapping the interplay of social and physical factors (e.g. building age, farm-related income, education level, access to farming facilities) that differentiate Iowa farming communities with unequal vulnerability. Semi-structured interview was used in this study to identify the determinants of vulnerability of farming communities to winter storms. Incorporating spatial analysis and factor analysis, this study quantified the effects of physical factors on the sensitivity and exposure of winter storms, and prioritized primary livelihood capitals that determine the adaptive capacity to winter storms. Current results have demonstrated the vulnerability patterns of farming communities to winter storms shaped under varying societal-physical environments and weather conditions. This research shows implications in livelihood pathways to transforming adaptations to vulnerability reduction.

Mapping Vulnerability of Farming Communities to Winter Storms in Iowa

GEOGRAPHY UNIVERSITY OF NORTHERN IOWA

Yiyi Zhang (zhangyao@uni.edu), Bingqing Liang

University of Northern Iowa

AGU100 ADVANCING EARTH AND SPACE SCIENCE

Why winter storms?

- Winter storms are the second-most frequent catastrophe in the Midwest (Andresen et al. 2012) and tend to create non-negligible impacts.
- Mid-latitude winter storms have increased in both intensity and frequency nationally due to the Arctic transitions from a relatively cold state to a warmer one (Cohen, Pfeiffer, and Francis 2018; Yao et al. 2017; Vose et al. 2014; Tang et al. 2013).
- However, few examples of studies were found to assess the vulnerability to winter storms.

Why farming communities?

- Vulnerability: the propensity or predisposition to be adversely affected (IPCC 2012).
- Farming communities are vulnerable because they highly rely on climatic-sensitive resources and activities (e.g. livestock husbandry).

How to measure vulnerability?

Vulnerability =
f [Exposure (+) + Sensitivity (+) - Adaptive Capacity (-)]
(Smit and Wandel 2006; IPCC 2001)

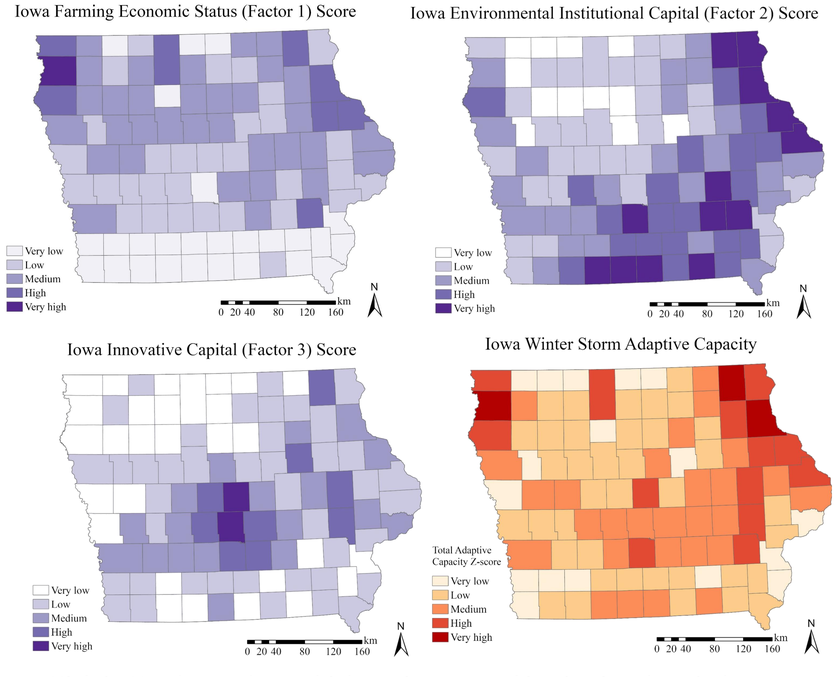
Vulnerability component	Variables
Exposure	• Occurrence of winter storm events (NWS) • Winter temperature variance (PRISM)
Adaptive capacity	• Natural capital: natural shelter (CropScape) • Physical capital: access to facilities (Iowa Facility Explorer), energy capacity (EPA Facility Registry Service), technology (USDA) • Financial capital: farm-related income (USDA) • Social capital: membership (requested from PFI), government program (USDA) • Human capital: household size (Census), labor (USDA), education (Census)
Sensitivity	• Animal commodities sale (USDA) • Building age (Census)

Factor analysis for adaptive capacity variables

- Estimating adaptive capacity is a key element of vulnerability assessment.
- Factor analysis: an exploratory technique to reduce a large number of variables into fewer numbers of interpretable underlying factors.
- "Farming economic status", "environment institutional capital" and "innovative capital" were extracted.

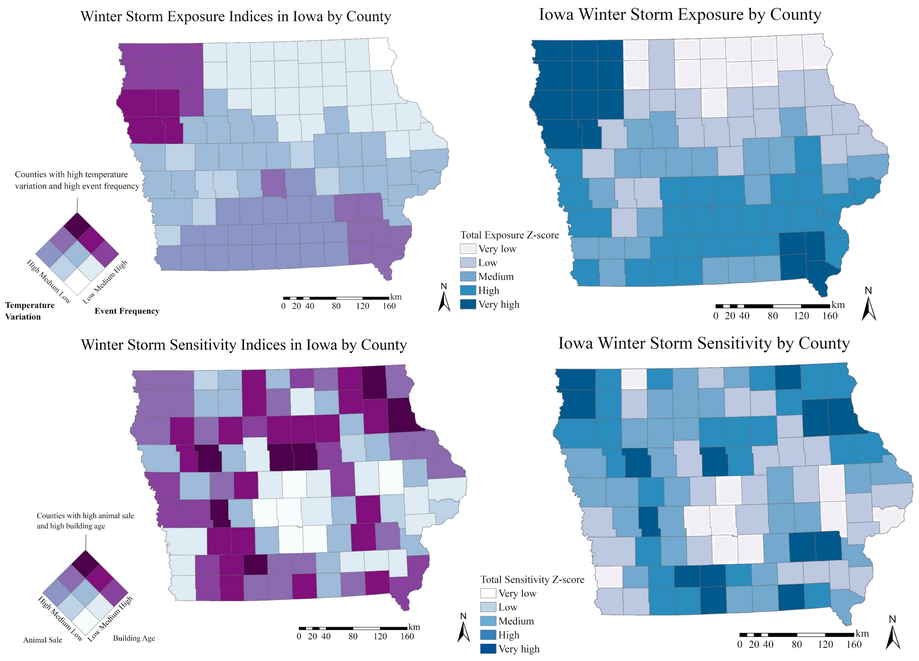
Variable	Component 1: Farming Economic Status	Component 2: Environmental Institutional Capital	Component 3: Innovative Capital
LaborExp	**0.930**	0.009	0.193
FarmIncome	**0.878**	-0.318	-0.047
Facilities	**0.810**	-0.294	-0.047
NaturalShelter	-0.189	**0.942**	0.043
GovExp	-0.205	**0.863**	-0.114
MembershipCount	-0.012	0.021	**0.922**
Education	0.110	-0.46	**0.914**
FeedExp	0.683	0.612	0.147
Variance explained (% Var)	35.611%	27.473%	22.4%
Cumulative variance explained	35.611%	63.084%	85.124%

Adaptive capacity



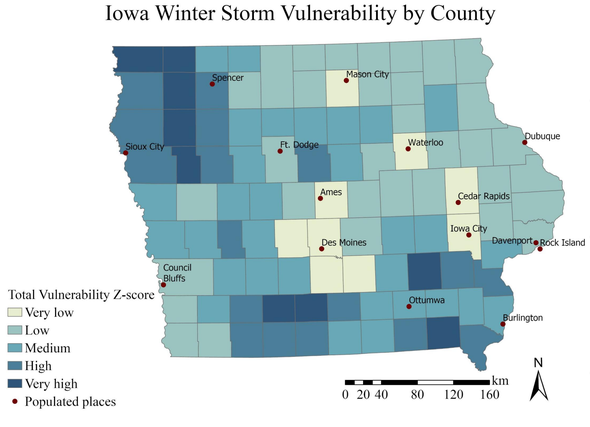
- High in Northeast due to high environmental institutional capital.
- Low in the Northwest due to low environmental institutional capital and innovative capital.
- Low in the South due to low farming economics.

Exposure and sensitivity



- Exposure is high in Northwest Iowa due largely to high event frequency.
- Exposure is high in South Iowa due largely to high temperature variation.
- Central Iowa is less sensitive due to low building age and animal sale.

Overall vulnerability and discussion



- High in the Northwest due to high exposure, consistent with the northeast's long history of severe winter storms and blizzards.
- High in the Northwest due partly to low environmental institutional capital. This is because the increase of monocultures have led to destructions of windbreaks.
- High in the Southeast due to relatively low farming economic status. This may be because of patchwork of small and diversified fields remains in the Southeast.
- Low in Central due to low sensitivity and innovative capital because of urban development.

Significant references

Andresen, Jeff, Steve Hilberg, Ken Kunkel, and Midwest Regional Climate Center. 2012. "Historical Climate and Climate Trends in the Midwestern USA." *US National Climate Assessment Midwest Technical Input Report*, 1–18.

Cohen, Judah, Karl Pfeiffer, and Jennifer A. Francis. 2018. "Warm Arctic Episodes Linked with Increased Frequency of Extreme Winter Weather in the United States." *Nature Communications* 9 (1).

Watson, Robert T., and Daniel Lee Albritton, eds. *Climate change 2001: Synthesis report: Third assessment report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, 2001.