

Montana Watershed Coordination Council  
Conservation Conversations  
November 9th, 2022

# Climate Change Vulnerability



Nick Silverman  
Adaptive Hydrology, LLC  
Missoula, MT

**Streamflow**

**Precipitation**

**Soil Moisture**

**Temperature**

**Snowpack**

**Sustainability?**

**Sensitivity?**

**Vulnerability?**

**Adaptive Capacity?**

**Resiliency?**

# Vulnerability?

...the extent to which a species, person, habitat, ecosystem, watershed, or place is susceptible to the impacts of a negative event

# How do we quantify vulnerability?

There are two main frameworks available:

## 1. Vulnerability as a component of risk (IPCC)

- a.  $\text{Risk} = \text{Exposure} \times \text{Hazard} \times \text{Vulnerability}$
- b. Exposure :: who/what is threatened
- c. Hazard :: occurrence/magnitude of an event
- d. Vulnerability :: likelihood of negative impact
  - i.  $V = \text{Sensitivity} \times \text{Adaptive Capacity}$

## 2. Vulnerability on its own

- a.  $\text{Vulnerability} = \text{Exposure} \times \text{Sensitivity} \times \text{Adaptive Capacity}$
- b. Exposure :: occurrence/magnitude of an event (say what???)



Key point => We need to be very clear about our definitions/frameworks

# Exposure

How much and what kind of climatic change?



# Sensitivity

How sensitive is the landscape or species to those changes?



# Adaptive Capacity

Ability of the landscape (or species) to cope with the change?





Vulnerability = f(Exposure, Sensitivity, Adaptive Capacity)

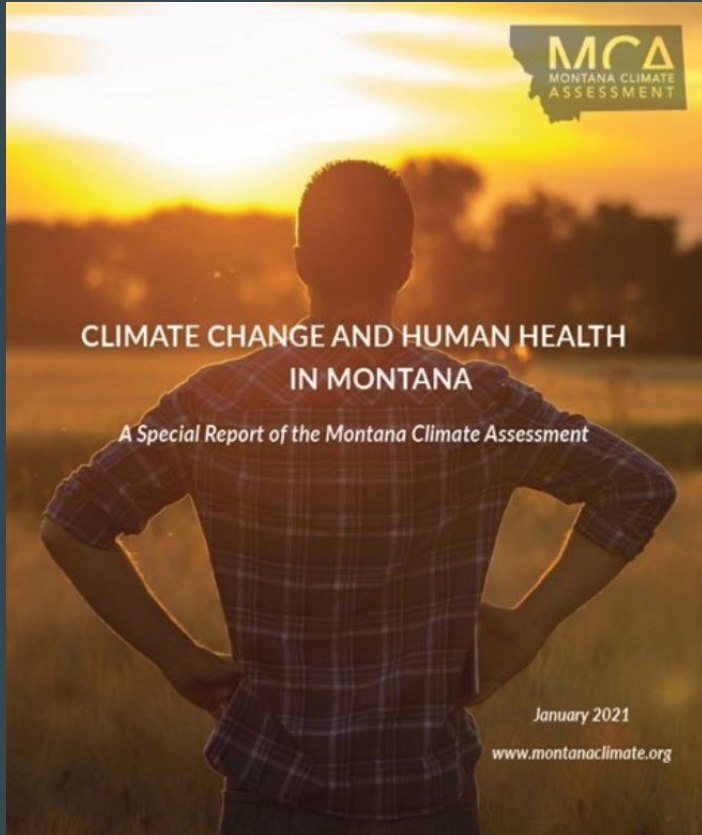
$$V = E + S - AC$$

$$V = \frac{E+S}{AC}$$

$$V = E * f(S, AC)$$

**A few examples...**

# 2021 Montana Human Health - Heat Vulnerability



# Layers for Analysis?

## Exposure

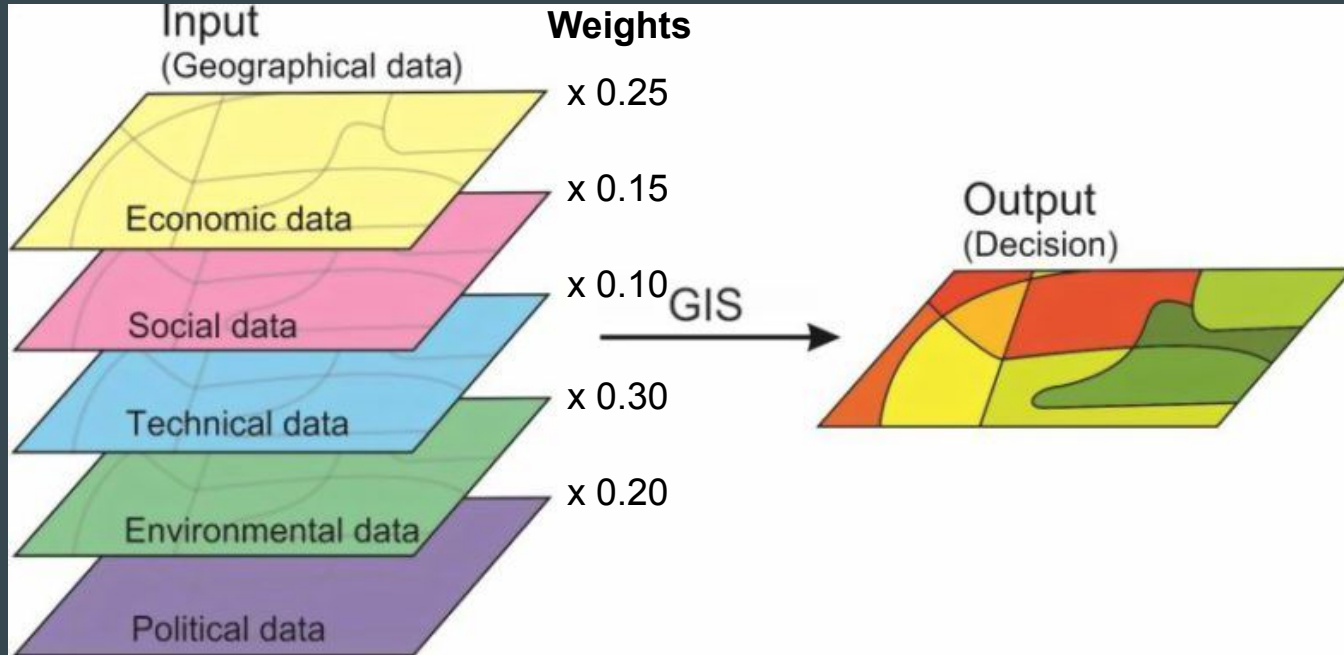
Historical Land Surface  
Temps. (Satellite)

Projected Change in Heat  
Index (Temp + Humidity)

## Sensitivity/Adaptive Capacity

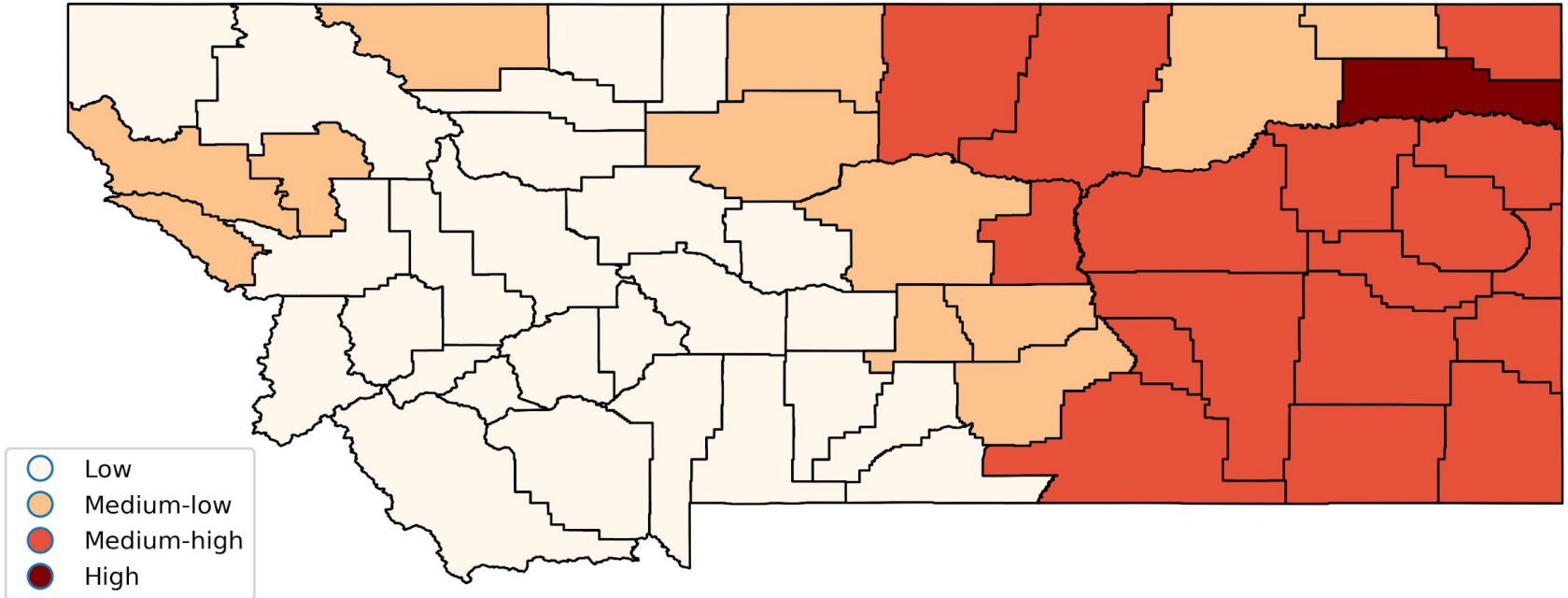
Income  
Poverty  
Child Poverty  
Construction jobs  
Transportation jobs  
Unemployment  
Professionally employed

# Equation - Multi-Criteria Decision Analysis



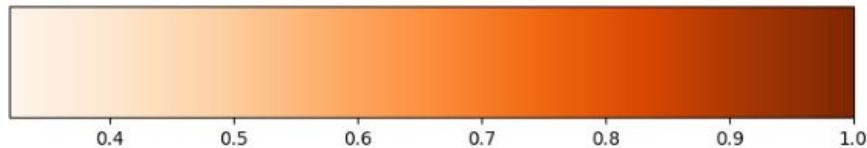
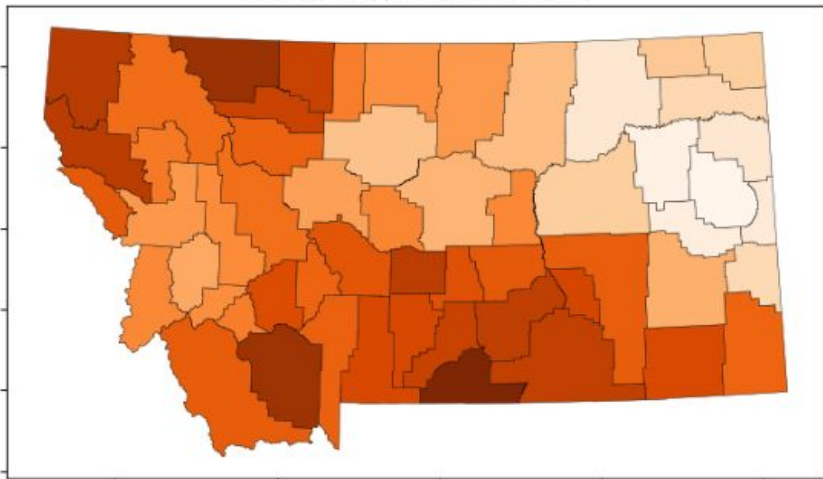
# Results

Vulnerability to Heat

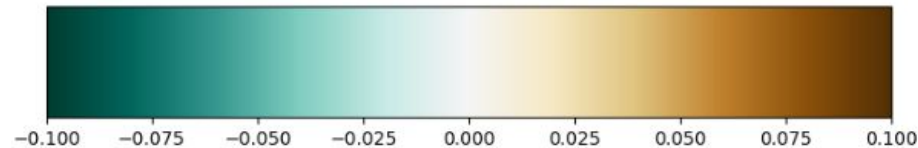
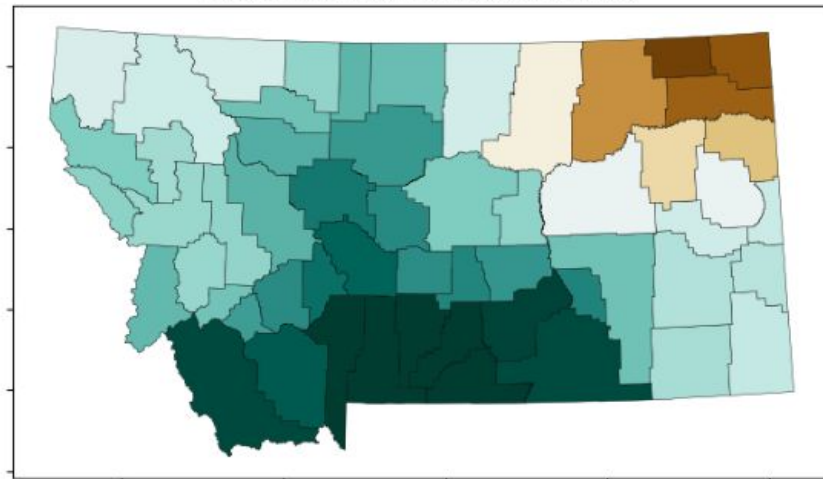


# 2023 MT DNRC Drought Plan - Exposure

Freq. in Drought (#) 2001-2020

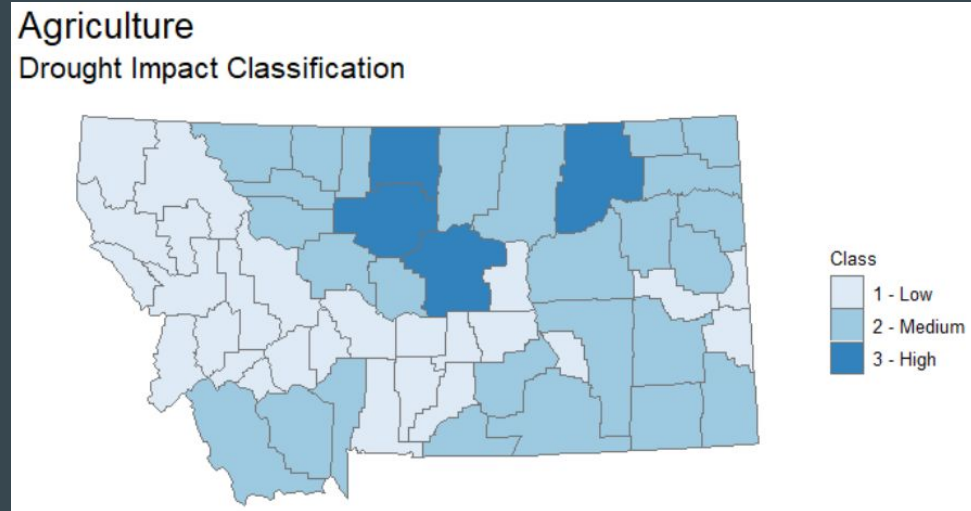


Change in Drought (D/year) 2001-2020



# Drought Plan - Sensitivity/Adaptive Capacity

- Uses quantitative and qualitative data
- Qualitative data comes from interviews
- Quantitative data comes from specific public sources
- Scores are standardized and then classified
- Three sectors of the economy are scored
  - Agriculture
  - Energy and Industry
  - Recreation and Tourism



Courtesy of JGR (<https://jgresearch.org>)



**How would you define and measure  
vulnerability to Climate Change?**

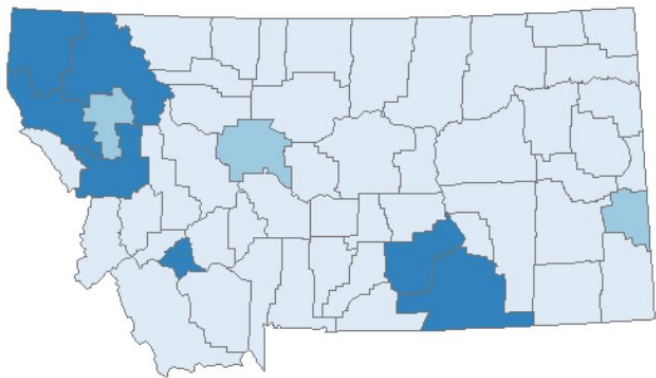
# Thank You!



Nick Silverman  
Adaptive Hydrology, LLC  
[nick@adaptivehydro.com](mailto:nick@adaptivehydro.com)  
406.233.9321

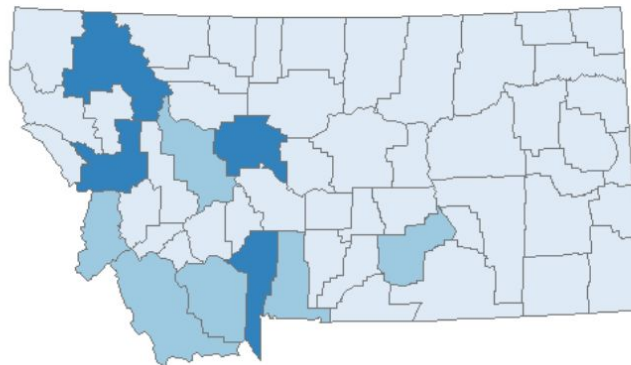
# Drought Plan - Sensitivity/Adaptive Capacity

Energy and Industry  
Drought Impact Classification



Class  
1 - Low  
2 - Medium  
3 - High

Recreation and Tourism  
Drought Impact Classification



Class  
1 - Low  
2 - Medium  
3 - High