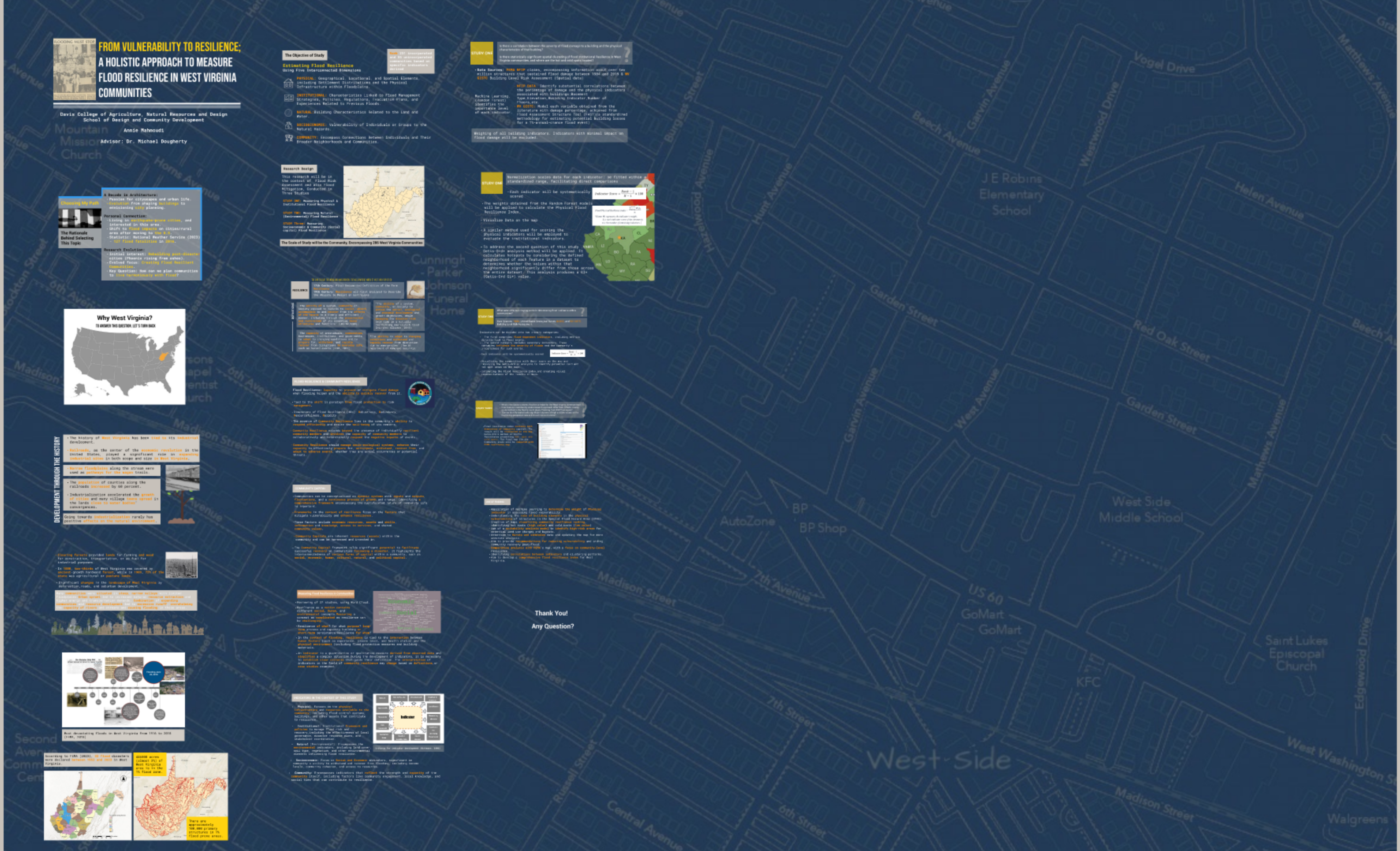
FLOODING MUST STOP
FROM VULNERABILITY TO RESILIENCE;
A HOLISTIC APPROACH TO MEASURE FLOOD RESILIENCE IN WEST VIRGINIA COMMUNITIES
Davis College of Agriculture, Natural Resources and Design
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Annie Mahmoudi
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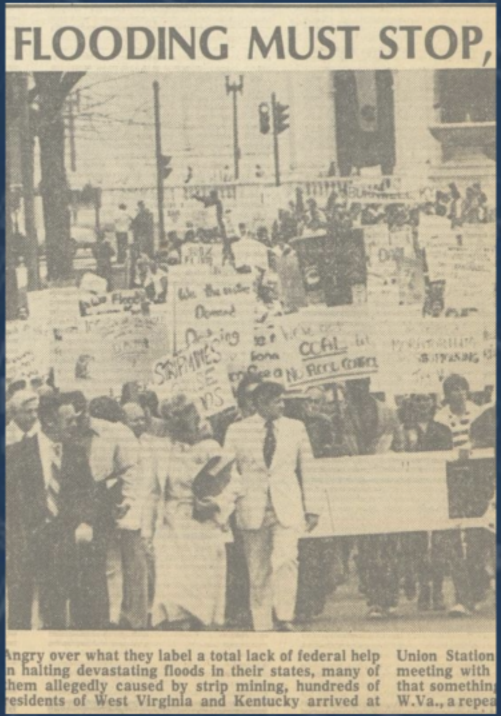
Why West Virginia?
DEVELOPMENT THROUGH THE HISTORY
Thank You!
Any Question?



FROM VULNERABILITY TO RESILIENCE; A HOLISTIC APPROACH TO MEASURE FLOOD RESILIENCE IN WEST VIRGINIA COMMUNITIES

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Choosing My Path

The Rationale Behind Selecting This Topic

A Decade in Architecture:

- Passion for cityscapes and urban life.
- Evolution from shaping buildings to envisioning city planning.

Personal Connection:

- Living in earthquake-prone cities, and interested in this area.
- Shift to flood impacts on cities/rural area after moving to the U.S.
- Statistic: National Weather Service (2023) - 127 flood fatalities in 2016.

Research Evolution:

- Initial interest: Rebuilding post-disaster cities (Phoenix rising from ashes).
- Evolved focus: Creating Flood Resilient Communities.
- Key Question: How can we plan communities to live harmoniously with flood?

Why West Virginia?

TO ANSWER THIS QUESTION, LET'S TURN BACK

DEVELOPMENT THROUGH THE HISTORY

- The history of **West Virginia** has been **tied to** its **industrial** development.

- **Railroads**, as the center of the **economic revolution** in the United States, played a significant role in **expanding industrial sites** in both scope and size **in West Virginia**.

- **Narrow floodplains** along the stream were used as **pathways for the wagon** trails.

- The **population** of counties along the railroads **increased** by 60 percent.

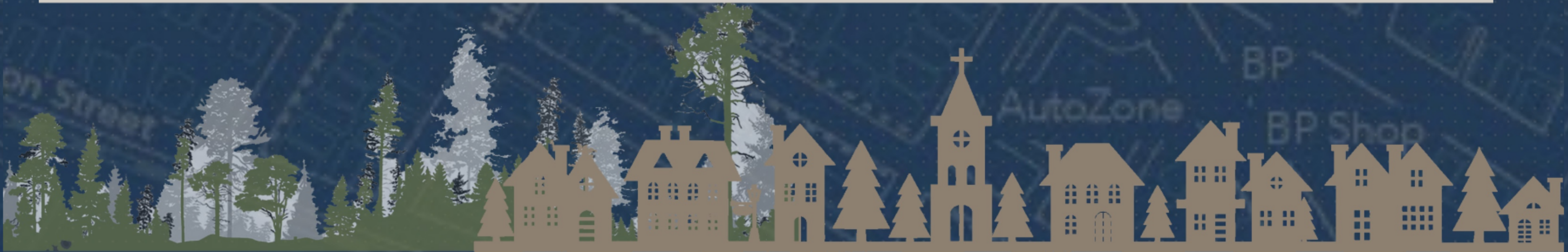
- Industrialization accelerated the **growth of cities** and many village **towns spread** in the lands **close to water bodies**' convergences.

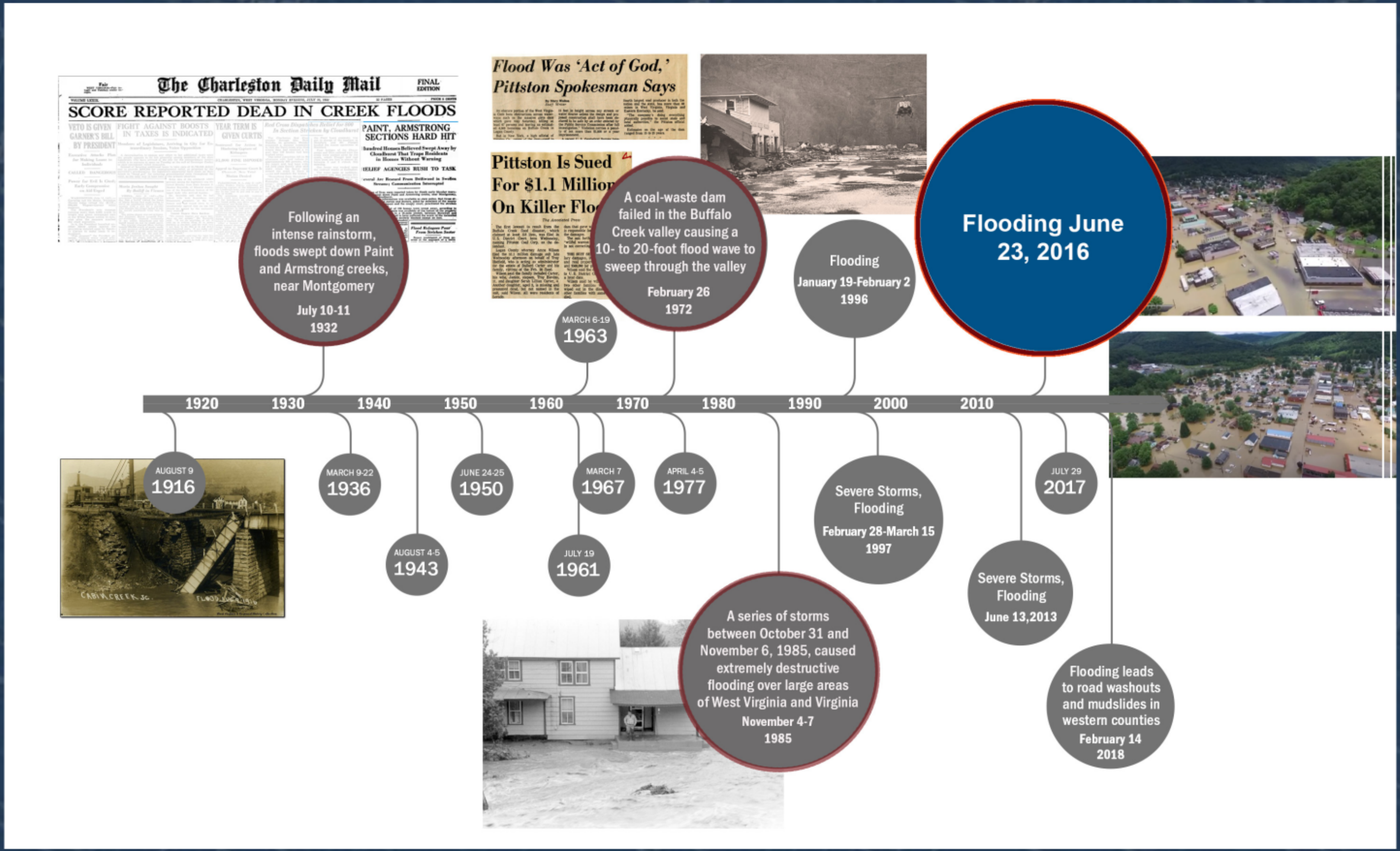
Going towards **industrialization** rarely has positive **effects on the natural environment**.

- Clearing forests provided lands for farming and wood for construction, transportation, or as fuel for industrial purposes.
- In 1880, two-thirds of West Virginia was covered by ancient-growth hardwood forest, while in 1909, 72% of the state was agricultural or pasture lands.

- Significant changes in the landscape of West Virginia by deforestion,roads, and suburban development.

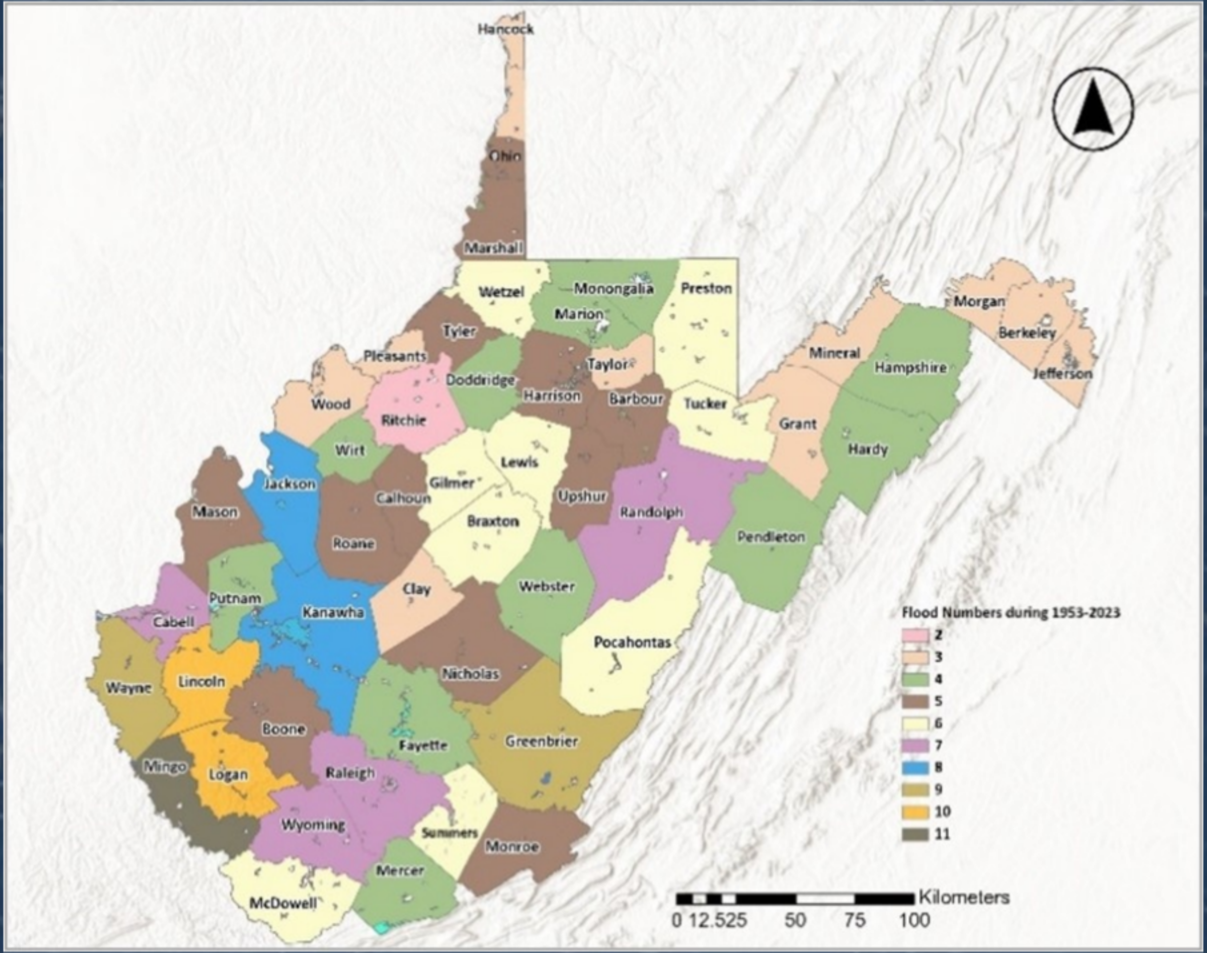
Many communities were situated in steep, narrow valleys with limited floodplains.Urban sprawl led to increased natural resource extraction and higher energy and transportation demands. Combination of expanding communities and resource development led to excessive runoff, overwhelming the capacity of rivers and streams and causing flooding in these areas.



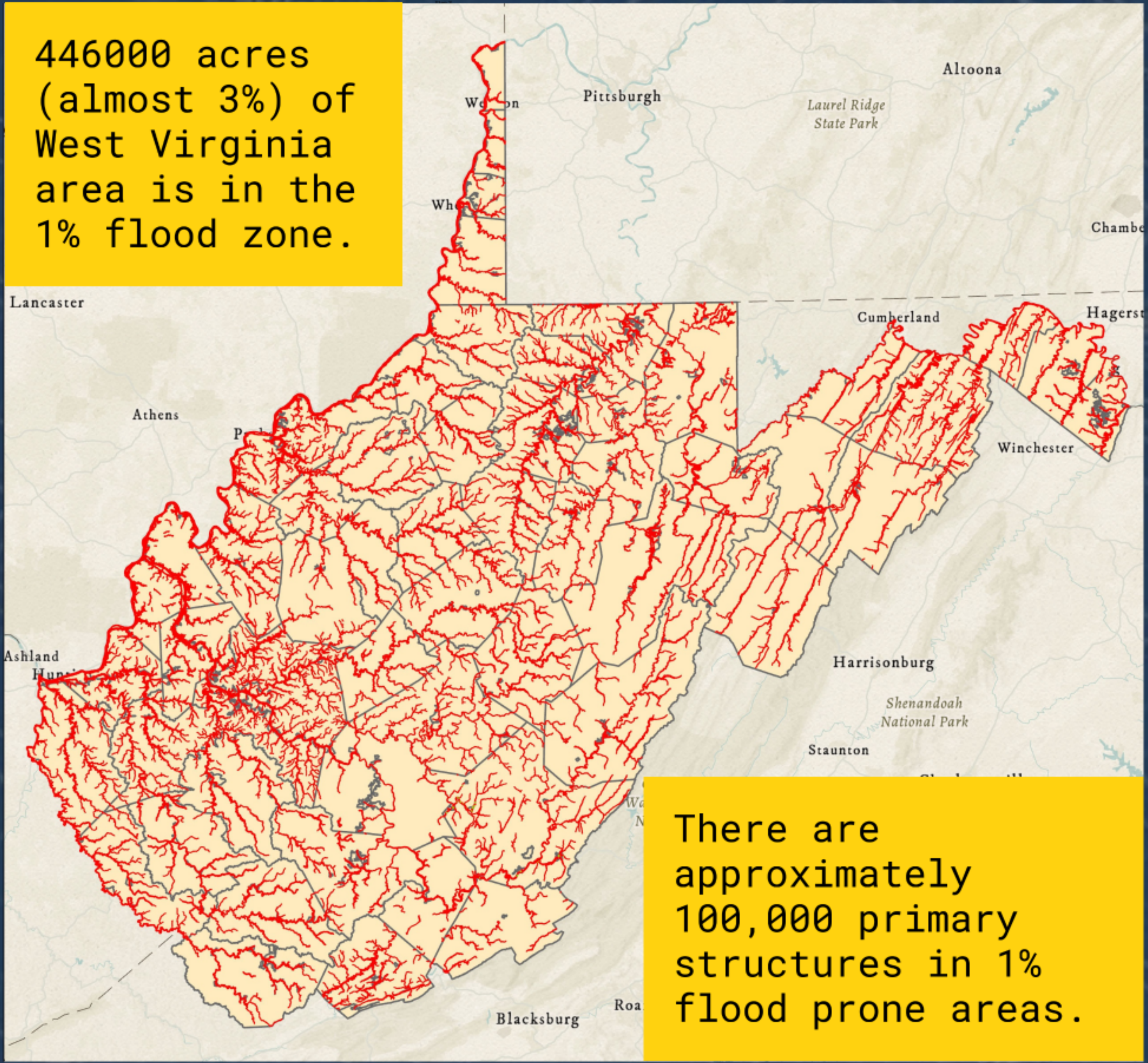


Most devastating floods in West Virginia from 1916 to 2018 (FEMA, 2018)

According to FEMA (2023), **32 flood** disasters were declared **between 1953 and 2023** in West Virginia.



446000 acres (almost 3%) of West Virginia area is in the 1% flood zone.



There are approximately 100,000 primary structures in 1% flood prone areas.

The Objective of Study

Rank 231 incorporated and 55 unincorporated communities based on specific indicators derived

Estimating Flood Resilience

Using Five Interconnected Dimensions

PHYSICAL: Geographical, Locational, and Spatial Elements, including Settlement Distributions and the Physical Infrastructure within Floodplains.

INSTITUTIONAL: Characteristics Linked to Flood Management Strategies, Policies, Regulations, Evacuation Plans, and Experiences Related to Previous Floods.

NATURAL: Building Characteristics Related to the Land and Water.

SOCIOECONOMIC: Vulnerability of Individuals or Groups to the Natural Hazards.

COMMUNITY: Encompass Connections Between Individuals and Their Broader Neighborhoods and Communities.

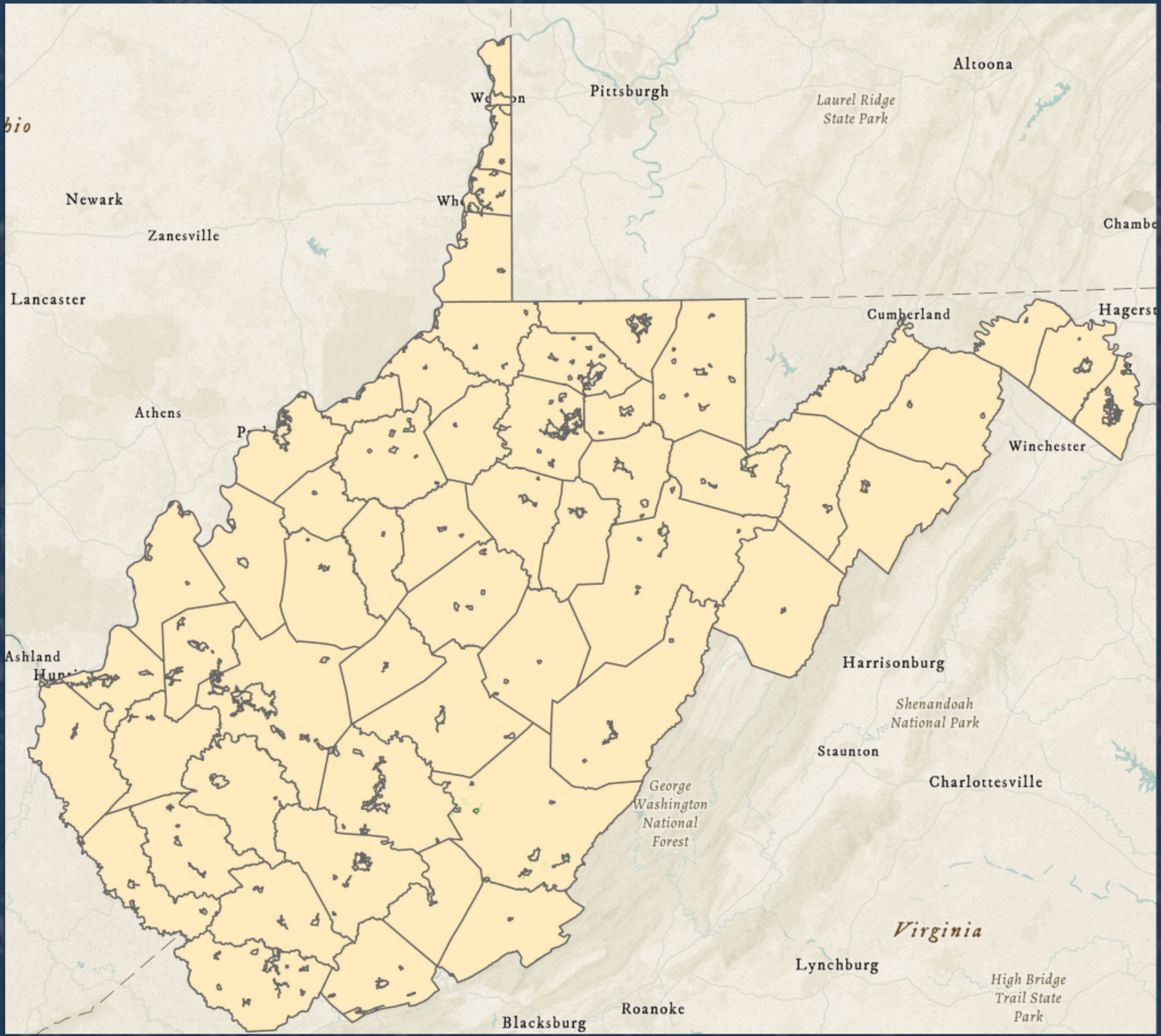
Research Design

This research will be in the context of Flood Risk Assessment and also Flood Mitigation, Conducted in Three Studies

STUDY ONE: **Measuring Physical & Institutional Flood Resilience**

STUDY TWO: **Measuring Natural (Environmental) Flood Resilience**

STUDY Three: **Measuring Socioeconomic & Community (Social capital) Flood Resilience**



The Scale of Study will be the Community, Encompassing 286 West Virginia Communities

THE OAK FOUGHT THE WIND AND WAS BROKEN; THE WILLOW BENT WHEN IT MUST AND SURVIVED

RESILIENCE

17th Century: First Documented Definition of the Term **Resilience**

19th Century: **Resiliency** was First Employed to Describe the Ability to Resist an Earthquake

DEFINITIONS

"The **ability of** a system, **community** or society exposed to hazards to **resist**, **absorb**, **accommodate** to and **recover** from the **effects of the hazard** in a timely and efficient manner, including through the **preservation and restoration** of its essential **basic structures** and functions" (UNSIDR,2009).

"The **ability** of a system, **community**, or society to **pursue** its **social**, **ecological**, and **economic development** and growth objectives, while **managing** its **disaster risk** over time in a mutually reinforcing way"(Zurich Flood Insurance Alliance, 2013).

"The **capacity** of individuals, **communities**, businesses, institutions, and governments to **adapt** to changing conditions and to **prepare** for, **withstand**, and **rapidly recover** from disruptions **to everyday life**, such as hazard events"(FEMA, 2017).

“The **ability** to **adapt** to **changing conditions** and **withstand** and **rapidly recover** from disruption due to emergencies" (The US Department of Homeland Security)

FLOOD RESILIENCE & COMMUNITY RESILIENCE

Flood Resilience: Capacity to **prevent** or **mitigate flood damage** when flooding happen and the **ability to quickly recover** from it.

- Tied to the **shift** in paradigm **from** flood **protection to** risk **management**.
- Dimensions of Flood Resilience (4Rs): **R**obustness, **R**edundancy, **R**esourcefulness, **R**apidity
- The essence of **Community Resilience** lies in the community's **ability** to **respond efficiently** and ensure the **well-being** of its members.
- **Community Resilience** extends **beyond** the presence of individually **resilient community members** and **involves** the **capacity** of **community members** to collaboratively and intentionally **respond** the **negative impacts** of events.
- **Community Resilience** should **manage socio-ecological systems, enhance** their **capacity** to effectively **prepare** for, **anticipate**, **withstand**, **recover from**, and **adapt to adverse events**, whether they are actual occurrences or potential threats.

COMMUNITY CAPITAL

- Communities can be conceptualized as **dynamic systems** with **inputs** and **outputs**, **fluctuations**, and a **continuous process of growth** and change. Identifying **a comprehensive framework** encompassing the multifaceted nature of community life is important.

- **Frameworks** in the **context of resilience** focus on the **factors** that mitigate vulnerability and **enhance resilience**.

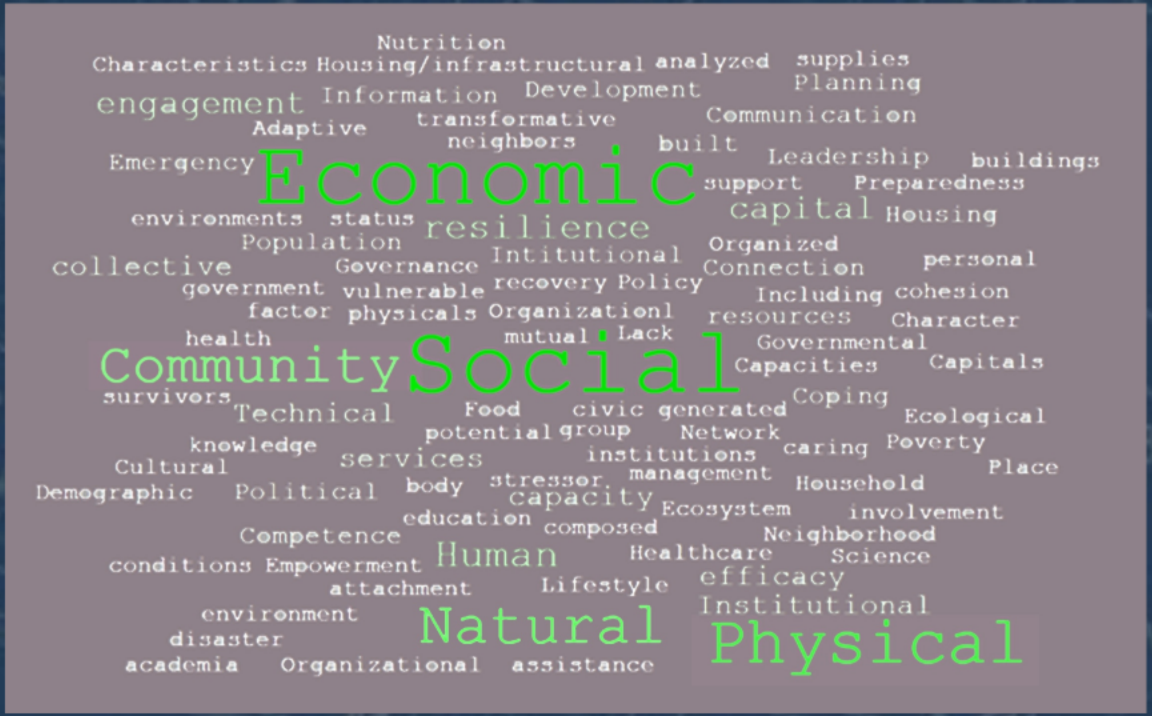
- These factors include **economic resources**, **assets** and **skills**, **information** and **knowledge**, **access to services**, and shared **community values**.

- **Community Capitals** are inherent **resources** (**assets**) within the community and can be harnessed and invested in.

- The **Community Capital** framework holds significant **potential** to **facilitate** successful **recovery** in communities **following a disaster**. It highlights the interconnectedness of **various forms of capital** within a community, such as **social**, **economic**, **human**, **cultural**, **natural**, and **political capital**.

Measuring Flood Resilience in Communities

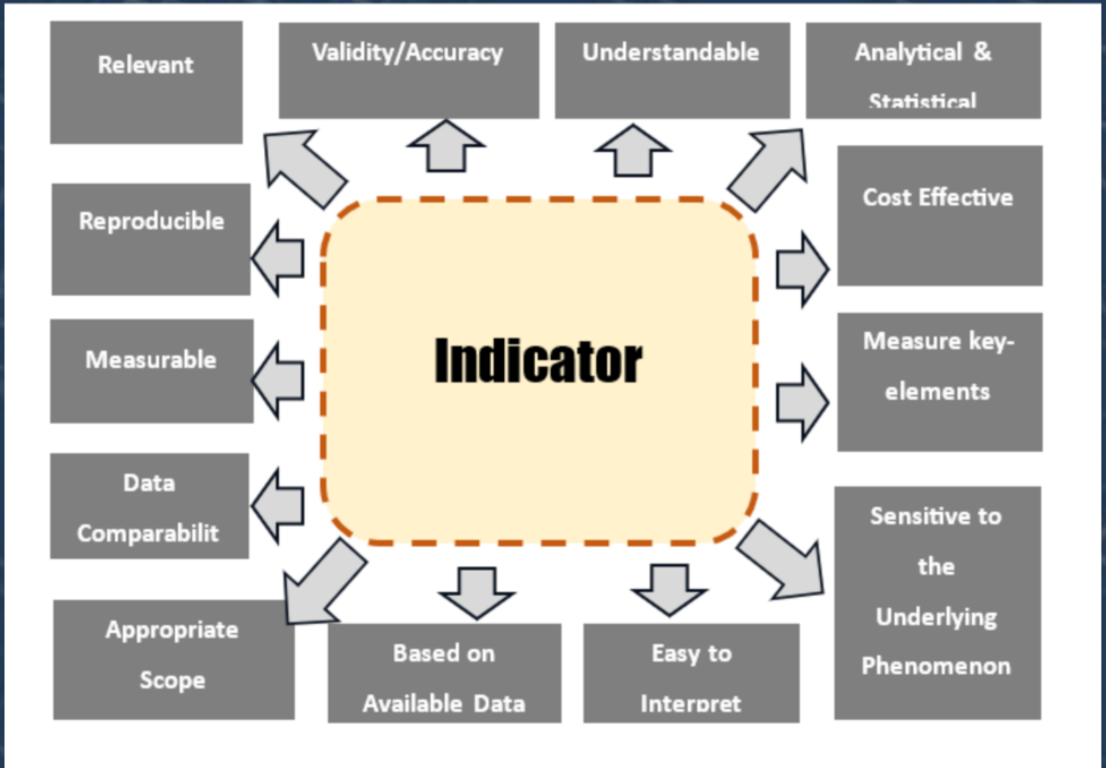
- Reviewing of 32 studies, using Word Cloud.
- Resilience as a **notion contains** different **social**, **human**, and **environmental** concepts.**Measuring** a concept as **complicated** as resilience can be **challenging**.
- Resilience **of what**? for what **purpose**? **long-term** process and capacity building **or short-term** persistence?Resilience **for whom**?



- In the **context of flooding**, **resilience** is tied to the **interaction** between **human factors** (such as experience, income level, and health status) and the **physical environment** (including flood protection measures and building materials.
- An **indicator** is a quantitative or qualitative measure **derived from observed data** and **simplifies** a complex situation.During the development of indicators, it is necessary to **establish clear criteria** that guide their definition. The **interpretation** of indicators in the field of **community resilience** may **change** based on **definitions**,or **case studies** examined.

INDICATORS IN THE CONTEXT OF THIS STUDY

- **Physical**: Focuses on the **physical infrastructure** and **resources available to the community**, including flood control systems, buildings, and other assets that contribute to resilience.
- **Institutional:** Institutional **framework and policies** to manage flood risk and recovery,including the effectiveness of local governance, disaster response plans, and stakeholder coordination.
- **Natural** (Environmental): Encompasses the **environmental** indicators, including land cover, soil type, vegetation, and other environmental elements influencing flood resilience.



Criteria for indicator development (Birkmann, 2006)

- **Socioeconomic**: Focus on **Social and Economic** indicators, significant in community's ability to withstand and recover from flooding, including income levels, community cohesion, and access to resources.
- **Community:** Encompasses indicators that **reflect** the strength and **capacity** of the **community** itself, including factors like community engagement, local knowledge, and social ties that can contribute to resilience.

STUDY ONE

Is there a correlation between the severity of flood damage to a building and the physical characteristics of that building?

Is there statistically significant spatial clustering of flood Institutional Resilience in West Virginia communities, and where are the hot and cold spots located?

- **Data Sources:** FEMA NFIP claims, encompassing information about over two million structures that sustained flood damage between 1984 and 2019 & **WV GISTC** Building Level Risk Assessment (Spatial data)

Machine Learning, (Random Forest) identifies the importance level of each indicator.

- **NFIP DATA:** Identify substantial correlations between the percentage of damage and the physical indicators associated with buildings:Basement Type,Elevation,Building Indicator,Number of Floors,etc.
- **WV GISTC:** Model each variable obtained from the literature with damage percentage, achieved from Flood Assessment Structure Tool (FAST)(a standardized methodology for estimating potential building losses for a 1%-annual-chance flood event)

Weighing of all building indicators. Indicators with minimal impact on flood damage will be excluded.

STUDY ONE

Normalization scales data for each indicator: be fitted within a standardized range, facilitating direct comparisons

- Each indicator will be systematically scored

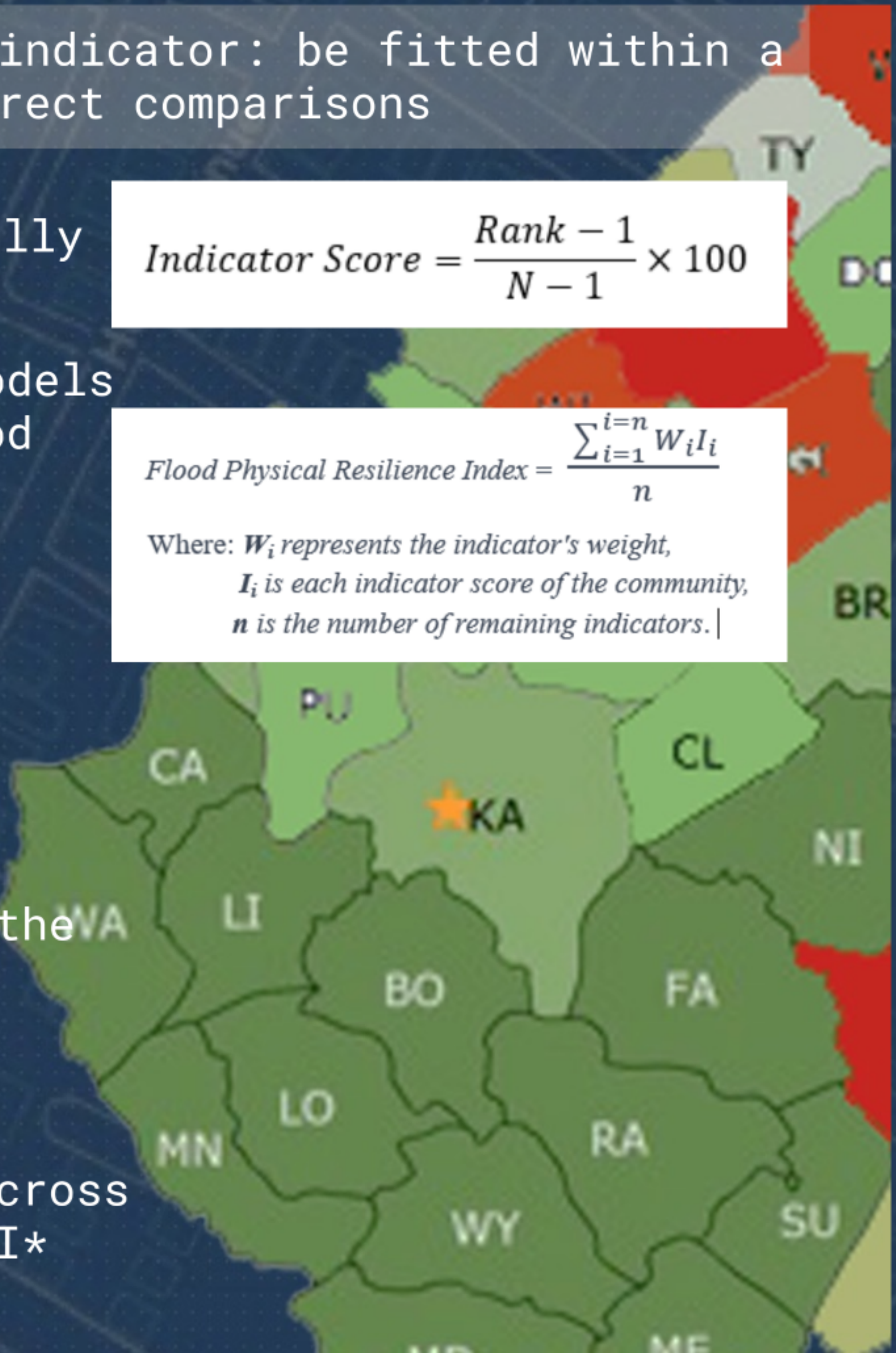
$$Indicator\ Score = \frac{Rank - 1}{N - 1} \times 100$$

- The weights obtained from the Random Forest models will be applied to calculate the Physical Flood Resilience Index.

$$Flood\ Physical\ Resilience\ Index = \frac{\sum_{i=1}^{i=n} W_i I_i}{n}$$

Where: W_i represents the indicator's weight,
I_i is each indicator score of the community,
n is the number of remaining indicators.

- Visualize Data on the map
- A similar method used for scoring the physical indicators will be employed to evaluate the institutional indicators.
- To address the second question of this study ,the Getis-Ord* analysis method will be applied. It calculates hotspots by considering the defined neighborhood of each feature in a dataset to determines whether the values within that neighborhood significantly differ from those across the entire dataset. This analysis produces a GI* (Getis-Ord Gi*) value.



STUDY TWO

What natural factors do play a role in determining flood resilience within communities?

Data Sources: FEMA, United States Geological Survey (USGS), and WV GISTC Building Level Risk Assessment.

Indicators can be divided into two primary categories:

- The first comprises **flood-dependent indicators**, including metrics directly tied to flood events.
- The second category includes secondary indicators. These variables **influence the severity of floods** and the community's preparedness for such events.
- Each indicator will be systematically scored

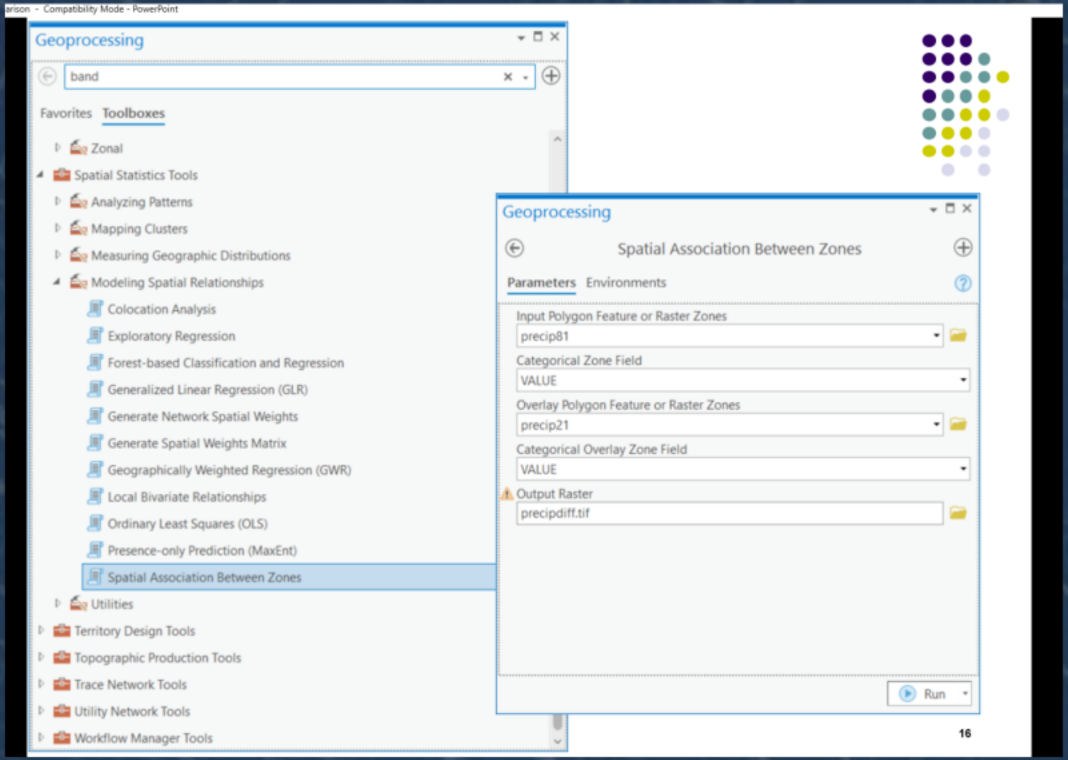
$$\text{Indicator Score} = \frac{Rank - 1}{N - 1} \times 100$$

- Visualizing the communities with their score on the map and Employing the Getis-Ord GI analysis, to identify potential cold and hot spot areas on the maps.
- Estimating the Flood Resilience Index, and creating visual representations of the results on maps.

STUDY THREE

- What is the Socioeconomic Resilience Index for the West Virginia communities?
- How does our community-scale research approach differ from FEMA's county-scale method in the Resilience Analysis Planning Tool (RAPT) analysis?
- Can we identify statistically significant clusters of high and low values on the map using geospatial data and visual representations?

- Final resilience index **contains both dimensions of community** capital. The result will be **visulazied on the map**. Getis-Ord G method in ArcPro facilitates presenting hot spot and cold spots. The final map (in the Community scale will be **compared with FEMA resilience map**.



USE OF FINDING

- Application of machine learning to **determine the weight** of **Physical indicator** in assessing flood vulnerability.
- Understanding the **role of building elements** in the **physical vulnerability** of structures in the Special Flood Hazard Area (SFHA).
- Creation of maps **visualizing community resilience ranking**, identifying hot spots (**high value**) and cold spots (**low value**)
- Use of a **suitability analysis model** to **identify high-risk areas** for potential land use changes and buyouts.
- Attention to **Karsts and sinkholes** data and updating the map for more accurate analysis.
- Aim to provide **recommendations for reducing vulnerability** and aiding community recovery post-flood.
- **Comparative analysis with FEMA**'s map, with a **focus on community-level** resilience.
- Identifying **correlations between indicators** and clustering patterns.
- Aim to develop a **comprehensive flood resilience index** for West Virginia.

Thank You!

Any Question?