FLOODING

AND CLIMATE CHANGE IN TRIBAL HAZARD MITIGATION PLANS

Floods typically fall into three major categories[1]:

Floods typically fall into three major categories:	Riverine flooding
	Coastal flooding
	Shallow flooding

Alluvial fan flooding is another type of flooding found primarily in the mountainous western states.[2]

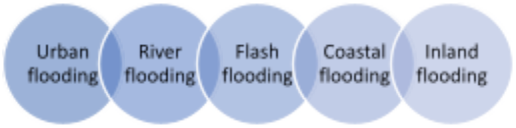
FLOODS CAN OCCUR QUICKLY

Flash floods are responsible for the greatest number of flood-related fatalities. Sudden heavy or intense rainfall can cause floods to occur in minutes to hours.

FLOODS CAN OCCUR SLOWLY

Rainfall can build up over hours, days, or weeks. Runoff from rainfall may create substantial flooding

Flooding can result from a river, or any water source, overflowing its banks, snowmelt, heavy rain, and breaches of levees and dams.



Areas damaged by wildfires are at risk for flash flood and debris flow during rainstorms[3].

[1] https://www.fema.gov/glossary/flood
[2] Alluvial Fan Flooding
[3] Post-Fire Flooding and Debris Flow

CLIMATE CHANGE AND FLOODING

Anthropogenic, or human-caused climate change threatens to impact the frequency, duration, and intensity of weather events, which may contribute to increased flood risk.[4] As a warming atmosphere can hold more water vapor, we can expect more moisture availability.[5] The water holding capacity of the air increases by about 7% per 1 degree Celsius warming.[6] This increased moisture availability can lead to changes in storm characteristics, and direct changes to precipitation events which increase the risk of flooding.[7] As the climate warms, these changes can create widespread, costly, and increasingly dangerous flood events. Climate change may impact large scale climate processes such as El Niño and La Nina events, atmospheric circulations like the Jet Stream, and atmospheric rivers, creating favorable flooding conditions in some regions.[8]

Floods can be impacted by both weather and human related factors.[9] Some weather factors include heavy precipitation, rapid snowmelt, storms, storm surges, and ice or debris jams. Human factors include anthropogenic climate change, infrastructure failure, and changes in land use.[10] Humans contribute to changes in weather related factors, due to human created warming increasing heavy rainfall events,

[4] POURING IT ON: How Climate Change Intensifies Heavy Rain Events
[5] Five things to know about flooding and climate change
[6] Climate Research 47:123
[7] POURING IT ON: How Climate Change Intensifies Heavy Rain Events
[8] Five things to know about flooding and climate change
[9] Floods
[10] Floods

widespread storm surges as a result of sea level rise, and more rapid snowmelt.[11] Some types of flooding, such as coastal flooding, are more impacted by changes in climate than other types. Flash floods and urban flooding are linked to heavy precipitation and are expected to increase with climate change.[12] The risk from future flooding is significant, considering urbanization, land use changes, climate change, and development in coastal areas as well as floodplains.[13] Scientists predict that heavy rainfall events will increase in the future.[14]

Impacts of climate change on flooding can be demonstrated by stronger storms, increase in intensity of hurricanes, and heavy precipitation events. These factors lead to a risk of flooding and storm surge, which can be amplified by sea level rise.[15]

HEAVY PRECIPITATION	• Heavy rainfall events projected to increase

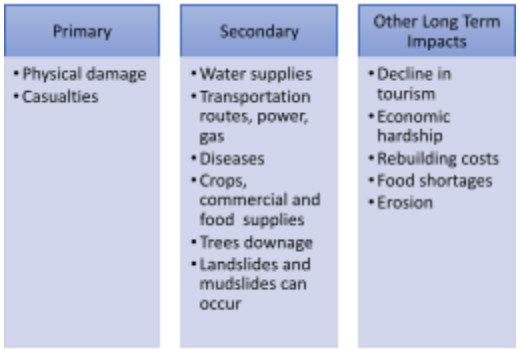
[11] Floods
[12] Floods
[13] The Human Impact of Floods: a Historical Review of Events 1980-2009 and Systematic Literature Review
[14] Five things to know about flooding and climate change
[15] Storms and Flooding: Implications of Climate Change: ERIT

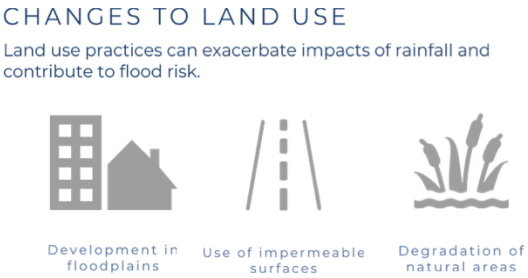
	• Rare events occurring at higher frequency • Climate change increases number and intensity of precipitation events because a warmer atmosphere can hold more water • Climate change alters weather patterns and precipitation characteristic • Can degrade water quality, overwhelm capacity • Scientists predict increases in extreme precipitation to continue across much of the United States
Hurricanes	• Hurricanes are one of the biggest contributors to flooding. Climate change can increase the strength and danger of hurricanes • Category 4 and 5 storms are increasing, along with hurricane wind speeds • expected to bring more rainfall, produce greater storm surge, have higher wind speed, and move slower • Rapid intensification of storms
Sea level Rise	• Loss of ice increases the volume of the world's oceans, causing sea levels to rise globally • Averaged globally, sea level is expected to rise by 2-7 feet over the course of the 21st century • Changes in sea level will impact regions differently based on • their geography and elevation • Amplifies near term vulnerability to storm surge

Cascading, Secondary Hazards

Flood risk can be increased when it is included in a compound event. A compound event can be described as two or more extreme events occurring successively or at the same time, or combinations of events that are not extreme events yet lead to an extreme event or impact when compounded.[16] For example, a high sea level at the same time as hurricane landfall. Increased flood events coupled with improper infrastructure can increase the hazard of events. The severity of these compound events have increased in many coastal cities. Many places will face these compounded impacts, resulting in increased risks to people and infrastructures.[17]

These can be described as Secondary Hazards. Common secondary hazards caused by flooding are landslides and erosion. Flooding may cause power outages or block critical evacuation routes. Finally, a cascading impact can be economic loss as a result of flooding. Damage from flooding can be put into three categories[18]:





[16] A typology of compound weather and climate events

[17] Overview - Fourth National Climate Assessment

[18] Secondary stressors and extreme events and disasters: a systematic review of primary research from 2010-2011

TOOLS AND APPROACHES TRIBES HAVE USED TO CONSIDER CLIMATE CHANGE AND FLOODING

CLIMATE CHANGE PLANNING APPROACHES: FLOODING

Many Tribes are taking steps to adapt to climate change impacts. The text below summarizes best practices to integrate flooding and climate change concerns.

To properly integrate climate change and flooding into planning, there are a diversity of approaches[19]:

Goals:

1. **Keeping future development out of hazard areas**
2. **Keeping floods from impacting existing developed areas**
3. **Strengthening existing development to resist hazards**

[19] Integrating the Local Natural Hazard Mitigation Plan into a Community's Comprehensive Plan

Methods[20]:

1. **Plan for Climate Change**
2. **Modify Land Use**
3. **Model Climate Risk**
4. **Repair and Retrofit Facilities**
5. **Construct new infrastructure**
6. **Monitoring events**
7. **Community driven initiatives and improved public engagement**

Examples:

- The **Quinault Indian Nation** partnered with university scientists at the University of Washington to help in planning for climate change. Their Tribal Hazard Mitigation Plan includes flooding and climate mitigation strategies such as:
    - *Shoreline management*
    - *Stream crossing update plan*
    - *A relocation plan to move critical infrastructure and residential houses that face recurrent flooding and tsunami inundation risk*
    - *Improving floodwalls*
    - *Installing floodgates*
    - *Participating in community assistance programs*
    - *Becoming part of the StormReady program*

A copy of the plan can be found: PUBLIC REVIEW DRAFT

- The **Snoqualmie Tribe** Hazard Mitigation Strategy can be found includes:
    - Locating future development outside of hazard prone areas
    - Developing Building Codes and Development/Master Plan that focuses new development and construction on hazard free areas, and Green Building Codes
    - Identify elders and other vulnerable populations to prioritize for assistance
    - Build protective flood infrastructure for historical/cultural sites and buildings
    - Implement vegetation management practices that utilize native plants and removal of invasive species to reduce flooding
    - Moving all tribal facilities out of the 100 yr floodplain
    - Utilize tribal casino revenue to move all tribal members into new houses that are outside of the 100 yr floodplain

[20] EPA Climate Change Adaptation Resource Center (ARC-X) https://www.epa.gov/arc-x/climate-impacts-water-utilities#tab-2

A copy of the plan can be found: Snoqualmie Tribe Hazard Mitigation Plan

CLIMATE CHANGE PLANNING TOOLS: FLOODING[21][22]

The resources listed below are examples of available resources that Tribes can use when planning. They are separated into three categories related to climate change, flooding, and general tribal tools and resources.

Climate change specific tools:

- **Scenarios Network for Alaska + Arctic Planning (SNAP) Tools**
- **Climate-Smart Conservation: Putting Adaptation Principles into Practice**
- **Climate Change Planning Tools for First Nations Guidebooks. 2006.**
- **Stormwater Calculator with Climate Assessment Tool**
- **Storm Surge Inundation and Hurricane Strike Frequency Map**
- **Scenario-Based Projected Changes Map**
- **RAINE, Resilience and Adaptation In New England**
- **ICLUS - Integrated Climate and Land Use Scenarios**
- **Environmental Justice Screening and Mapping Tool**
- **CREAT, -** Climate Resilience Evaluation and Awareness Tool
- **Climate Ready Estuaries (CRE)**
- **US Climate Resilience Toolkit | US Climate Resilience Toolkit**
  - Case Studies
- **USGS Coastal Change Hazards Portal**
- **Surging Seas: Sea level rise analysis by Climate Central**
- **NOAA Sea Level Rise Viewer**
- **Adapting Stormwater Management for Coastal Floods**
- **Managed Retreat Toolkit » Introduction**
- **Climate Change Adaptation Certification Tool: IDENTIFY EVALUATE DETERMINE** - EcoAdapt, Foresight Partners Consulting
- **Climate Action Resource Center** NCAI Climate Action Resource Center (CARC - National Congress of American Indians)
- Climate Prediction Center - National Weather Service **Global Monsoons: North American Precipitation**
- **Digital Coast - NOAA Digital Coast Home**
- Strategies for Climate Change Adaptation -EPA **Strategies for Climate Change Adaptation | Climate Change Adaptation Resource Center (ARC-X)**
- **AgroClimate – Tools for Managing Climate Risk in Agriculture**

Flooding specific tools:

- **Federal Emergency Management Agency (FEMA) Floodplain Management Requirements** – www.fema.gov/floodplain-management-requirements
- **FEMA Floodplain Management Tools** – www.fema.gov/floodplain-managers
- **No Adverse Impact Floodplain Management** No Adverse Impact Floodplain Management Tool, Association of State Floodplain Managers Toolkit: NAI Toolkit8
- **River Forecasts - National Weather Service NOAA**
- **Extreme Water Levels - NOAA Tides & Currents**
- **United States Interagency Elevation Inventory**
- **Flood Resilience Checklist**
- **NOAA Coastal Flood Exposure Mapper**
- **Storm Water Management Model (SWMM) | US EPA**

[21] Tribal Nations Tools - Assessment & Planning
[22] Tribal Profiles, Fact Sheets and Climate Planning Tools | Tribal Climate Change