The Hutchins Water Center at Colorado Mesa University is pleased to host the 12th annual

UPPER COLORADO RIVER BASIN WATER FORUM

October 30–31, 2023

Grand Junction, Colorado

RESHAPING THE RIVER

Reimagining Water Use and Management in the Upper Colorado River Basin

BABBITT CENTER FOR LAND AND WATER POLICY

A Center of the Lincoln Institute of Land Policy

Water Security Index in the Colorado River Basin (WSICRB) Cases from the Upper Basin: Grand Junction, Colorado.

Presented by:

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Fall 2023

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Fuente: NASA

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Sustainable Development

"It is within humanity's power to ensure that development is sustainable, that is, to ensure it meets the needs of the present without compromising the ability of future generations to meet their own."

From Our Common Future, UN 1987.

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Fuente: UN, 1987

The water resource is unique because, in addition to being essential for life, it does not have an equivalent substitute so far. It is used in the production of ALL goods and services, with no natural or synthetic resource that can replace it.

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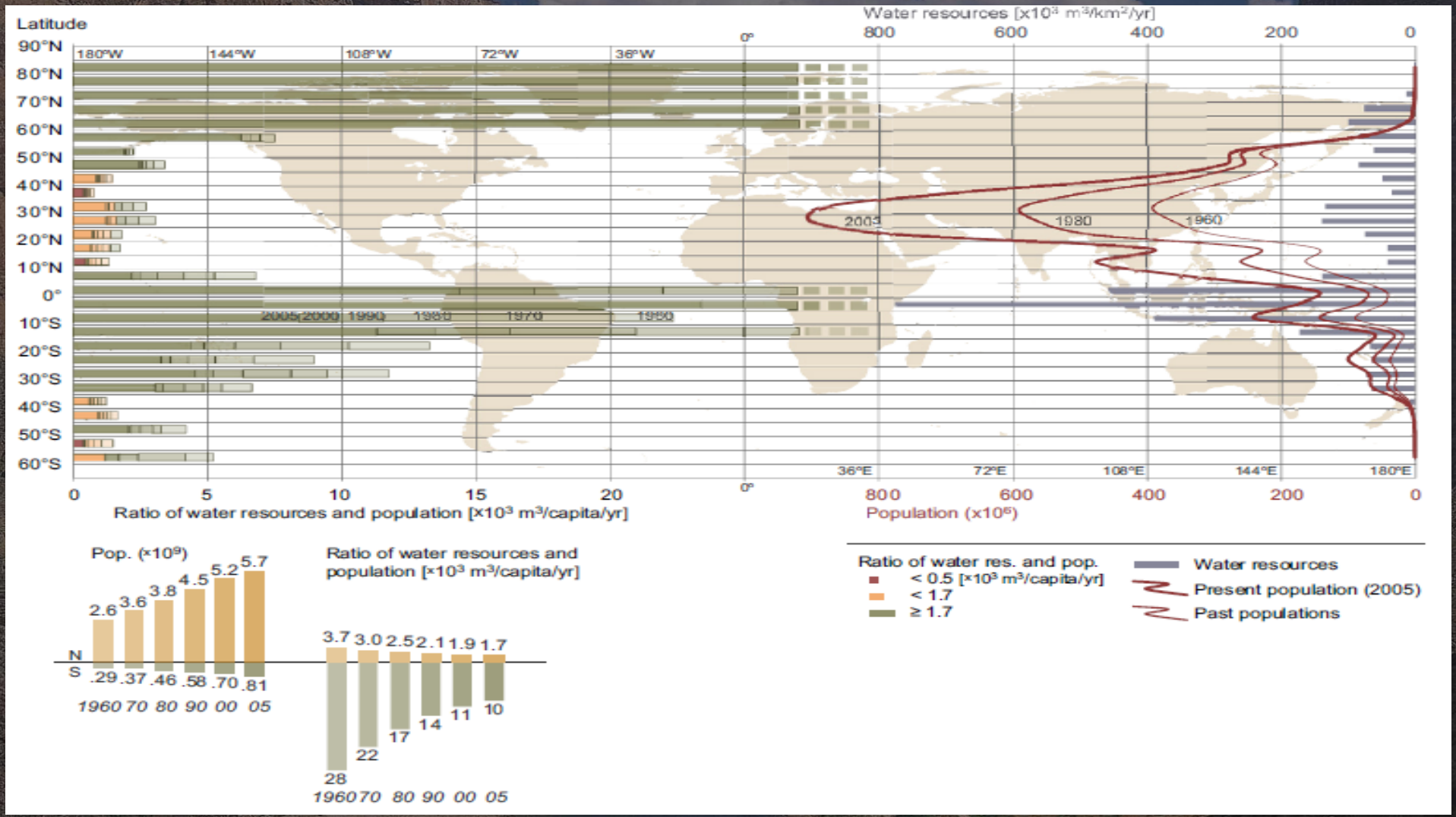
Global risks ranked by severity over the short and long term

"Please estimate the likely impact (severity) of the following risks over a 2-year and 10-year period"

Natural Resources crisis (Water Crisis):

"A significant decrease in the quality and quantity of available drinking water, resulting in adverse effects on human health and/or economic activity."

Fuente: The Global Risk Report 2023, 16h Edition (WEF,2023)



Fuente: The world by latitudes: a global analysis of human population, development level and environment across the north-south axia over the past half century (Kummu & Varis, 2011)

Water Security Concept

"***Water Security*** *is defined here as the ability of a population to safeguard sustainable* ***access*** *to adequate* ***quantities*** *of water of acceptable* ***quality*** *to maintain livelihoods, human well-being and socio-economic development, to ensure protection against waterborne pollution and* ***water-related disasters****, and to preserve ecosystems in a climate of peace and political stability*"

(UN-WATER, 2013).

Water Security Concept

Two approaches have been established regarding this concept :

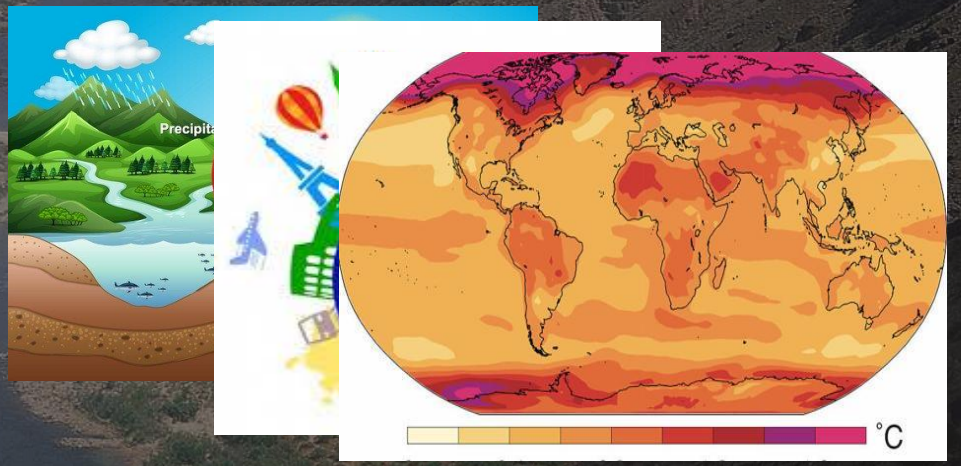
- Specific disciplinary definitions.
- Multidisciplinary and integrative definitions.

Whichever approach is taken, achieving Water Security is defined by many factors, and three in particular stand out:

1.- Hydrological environment,

2.- The socioeconomic environment,

3.- Expected future changes.



Water Security Index in the Colorado River Basin (WSICRB)

General Objectives:

To propose, construct and implement a Water Security Index for a strategic region within the Colorado River Basin.

Specific Objectives:

To propose components and a calculation methodology for the WSICRB.

To evaluate the status of the established components of the WSICRB.

To implement the WSICRB within a strategic region at the watershed level.

To build and represent the WSICRB in a GIS that serves as a tool for integrated water management.

Water Security Index in the Colorado River Basin (WSICRB)

The proposed calculation of the WSICRB is defined as a *geometric mean* of the components in a HUC10, since it does not mask the low values and prevents each value from having the same incidence in the result (UNDP, 2019). its calculation is performed according to the following formula:

$$WSICRB = \left(\prod_{i=1}^{M} WSICRB_{i-n} \right)^{1/M}$$

Where:

$WSICRB_{i\text{-}n}$ = Components to Evaluate Water Security, dimensionless.
M = Number of components.

Dimension, Components and indicators

$$WSICRB = \left(WSICRB_i * WSICRB_j * WSICRB_k * WSICRB_l\right)^{1/4}$$

WSICRB		
DIMENSION	**COMPONENTS**	**INDICATORS**
Availability And Quality	Water availability ($WSICRB_i$)	*Water Scarcity Index (WSI)*
		Groundwater Extraction Index (GEI)
	Water Quality ($WSICRB_j$)	*Water Quality Index (WQI)*
Water Supply	Accessibility ($WSICRB_k$)	*Water Supply Users Proportion (WSUP)*
Water Hazards	Potencial Risks ($WSICRB_l$)	*Expected Annual Loss (EAL)*
		Social Vulnerability (SV)
		Community Resilience (CR)

WSICRB Summary of Proposals

WATER SECURITY INDEX IN THE COLORADO RIVER BASIN (WSICRB)

EQUATION:

$$WSICRB = \left(\prod_{i=1}^{M} WSICRB_{i-n} \right)^{1/M}$$

DIMENSION	COMPONENTS	INDICATORS
Availability And Quality	Water availability ($WSICRB_i$)	$WSICRB_i = WSI * F_a + GEI * F_b$
	Water Quality ($WSICRB_j$)	$WSICRB_j = WQI$
Water Supply	Accessibility ($WSICRB_k$)	$WSICRB_k = WSUP$
Water Hazards and Climate Change	Potencial Risks ($WSICRB_l$)	$WSICRB_l = NRI$

WSICRB Classification

WSICRB	
Degree	**Value**
Extremelly High	*WSICRB* > 0.81
High	0.61 < WSICRB <= 0.80
Moderate	0.40 < WSICRB <= 0.60
Low	0.00 < WSICRB <= 0.01
Very Low	0.00 < WSICRB <= -0.39
Extremely Low	*WSICRB* < - 0.40

WSICRB	
Degree	**Value**
Extremelly High	*WSICRB* > 0.91
High	0.81 < WSICRB <= 0.90
Moderate	0.71 < WSICRB <= 0.80
Low	0.51 < WSICRB <= 0.70
Very Low	0.31 < WSICRB <= 0.50
Extremely Low	*WSICRB* < 0.30

Water availability ($WSICRB_i$)

$$WSICRB_i = (WSI * F_a) + (GEI * F_b)$$

Where:

WSI = Water Scarcity Index (dimensionless).

GEI = Groundwater Extraction Index (dimensionless)

F_{a-b} = Weighting factor of the indicator.

$$WSI = \frac{W_i}{WA_i - EWR_i}$$

$$GEI = \frac{GW}{R}$$

***WSICRB*$_i$**	
Grado	**Valores**
Extremelly High	*WSICRB*$_i$ > 0.91
High	0.81 < WSICRB$_i$ <= 0.90
Moderate	0.61 < WSICRB$_i$ <= 0.80
Low	0.21 < WSICRB$_i$ <= 0.6
Very Low	*WSICRB*$_i$ < 0.20

Source:Smakhtin, Revenga, & Döll, 2004; Vörösmarty, Douglas, Green, & Revenga, 2005; Gain, Giupponi, & Wada, 2016

Water Quality ($WSICRB_j$)

$$WSICRB_j = WQI$$

Where:

WQI = Water Quality Index (*Dimensionless*).

$$WQI = \frac{\sum I_i W_i}{\sum W_i}$$

Where:

$W_i =$ Weighting factor for each parameter.

$I_i =$ Subindex value expressed in Water Quality Index (WQI).

WSICRB$_j$	
Degree	**Value**
Very Good	*WSICRB*$_j$ > 0.90
Good	0.71 < WSICRB$_j$ <= 0.90
Moderate	0.51 < WSICRB$_j$ <= 0.70
Bad	0.26 < WSICRB$_j$ <= 0.50
Very Bad	*WSICRB*$_j$ < 0.25

Source: NFS (2022); Canter (1998).

Accessibility ($WSICRB_k$)

$$WSICRB_k = WSUP$$

Where:

WSUP = Water Supply Users Proportion (Dimensionless).

$$WSUP = \frac{No.\,of\ Water\ supply\ Users}{Total\ population}\ x\ 100$$

$WSICRB_k$	
Degree	**Value**
Extremelly High	$WSICRB_k > 0.95$
High	$0.86 < WSICRB_k <= 0.95$
Moderate	$0.76 < WSICRB_k <= 0.85$
Low	$0.60 < WSICRB_k <= 0.75$
Very Low	$WSICRB_k < 0.60$

Potencial Risks ($WSICRB_I$)

$$WSICRB_I = NRI$$

Where:

NRI = National Risk Index *(Dimensionless).*

$$NRI = \frac{EAL * SV}{\mathrm{CR}}$$

Where:

EAL = Expected Annual Loss (Adimensional).

SV = Social Vulnerability (Adimensional).

CR = Community Resilience (Adimensional).

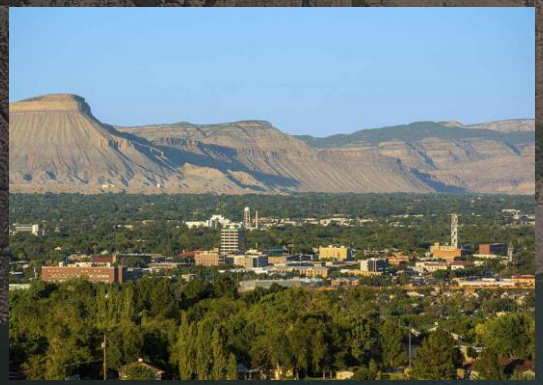
WSICRB$_I$	
Degree	**Value**
Very Low	*WSICRB$_I$* > 0.87
Relatively Low	0.81 > WSICRB$_I$ =< 0.87
Relatively Moderate	0.74 > WSICRB$_I$ =< 0.81
Relatively High	0.63 > WSICRB$_I$ =< 0.74
Very High	*WSICRB$_I$* <= 0.63

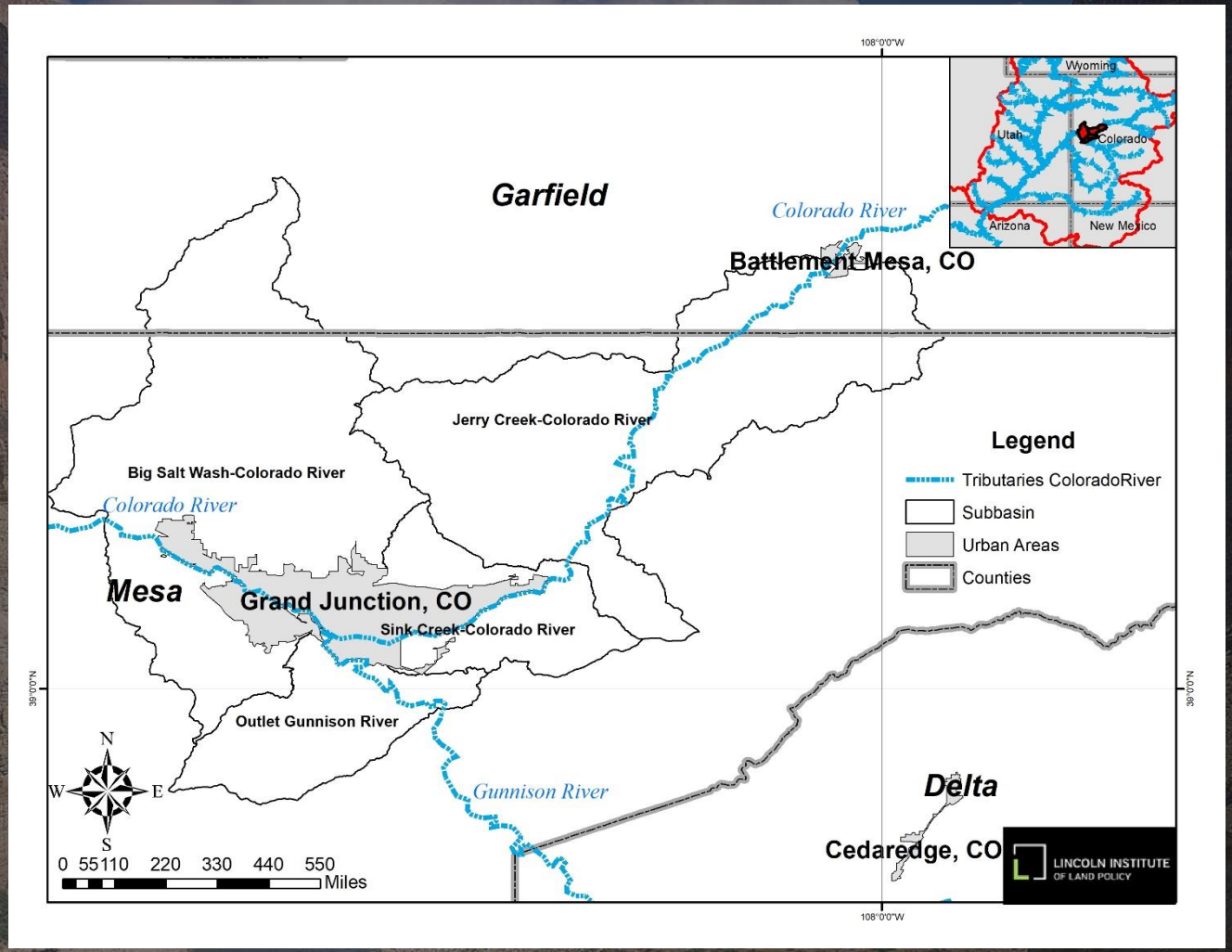
Source: FEMA,2021

Grand Junction Area

Description of Study Areas.

Grand Junction Area





HUC10

#	Name	Area km^2
1	Jerry Creek - Colorado River	913.61
2	Big Salt Wash - Colorado River	1,077.34
3	Sink Creek - Colorado River	296.16
4	Outlet Gunnison River	269.39

Source: DNS (2022) and CWCB(2022).

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Implementation of the WSICRB.

Water availability ($WSICRB_i$)

Grand Junction Area

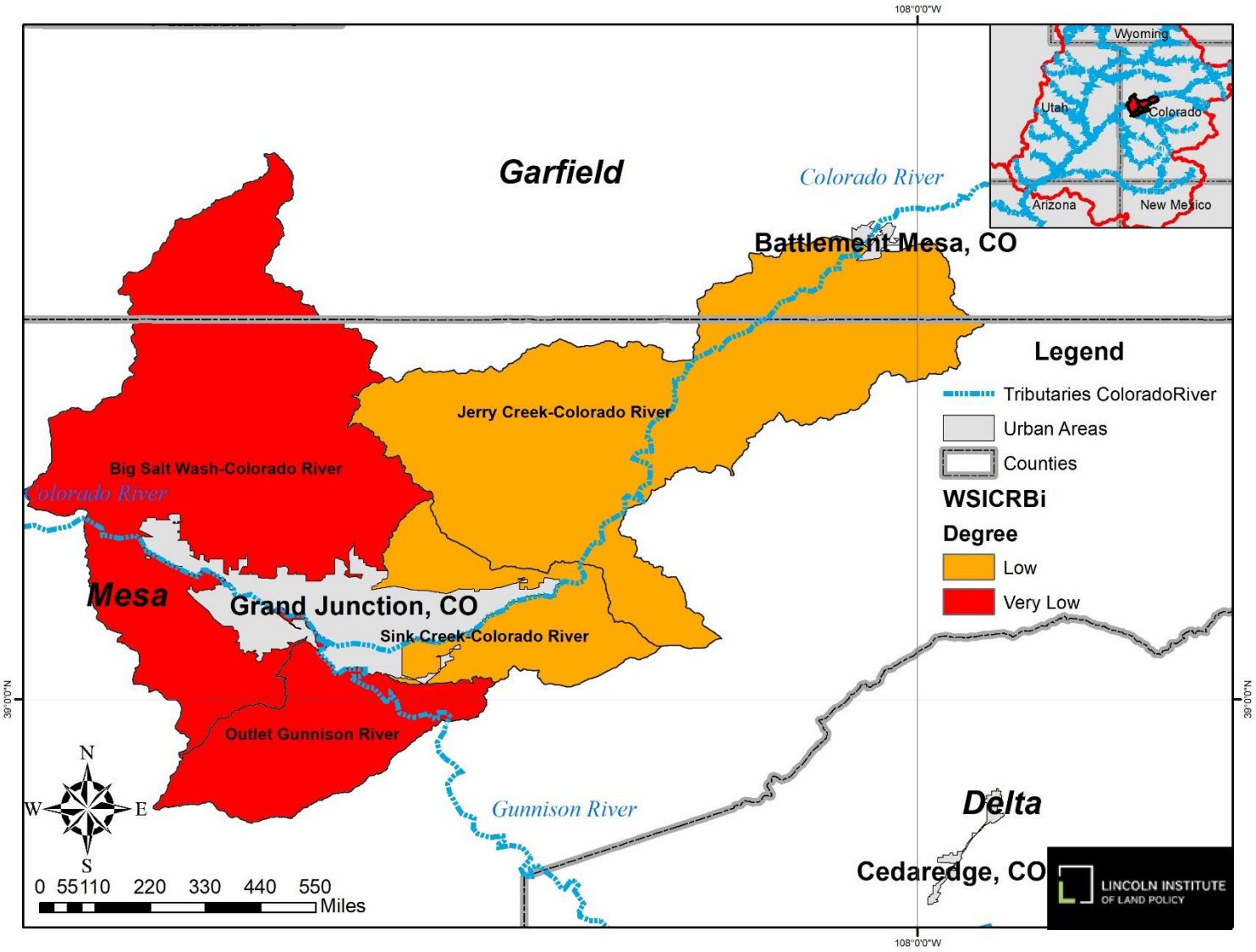
WATER AVAILABILITY ($WSICRB_i$)

#	Subbasin	WSI	Degree	GEI	Degree	F_a	F_b	$WSICRB_i$	Degree	Normalized Value	
1	Jerry Creek - Colorado River	-0.4327	Very Low	0.984	Extremelly High	98.55%	1.45%	-0.412	Very Low	0.294	Low
2	Big Salt Wash - Colorado River	-0.5015	Very Low	0.982	Extremelly High	98.51%	1.49%	-0.479	Very Low	0.260	Low
3	Sink Creek - Colorado River	-0.7430	Very Low	0.997	Extremelly High	98.43%	1.57%	-0.716	Very Low	0.142	Very Low
4	Outlet Gunnison River	-0.8421	Very Low	0.997	Extremelly High	98.34%	1.66%	-0.812	Very Low	0.094	Very Low

Source:

- Dieter et. al (2018): Estimated use of water in the United States county-level data for 2015 (ver. 2.0, June 2018).
- DNR (2015). Colorado Water Plan 2015.
- USGS (2016). Ground Water Atlas of the United States: Colorado Plateaus Aquifers.

Water availability ($WSICRB_i$)



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Implementation of the WSICRB.

Water Quality ($WSICRB_j$)

Grand Junction Area

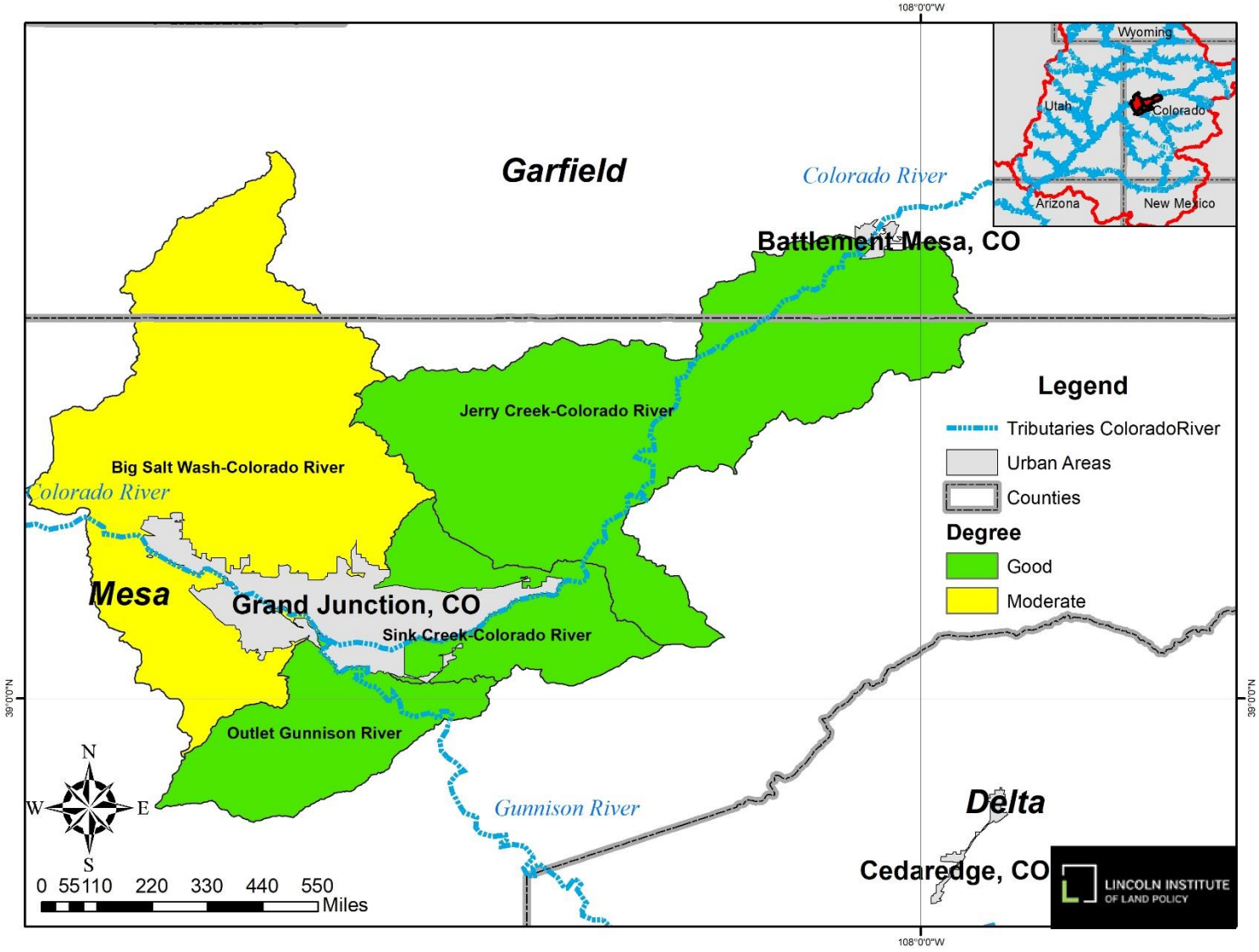
Water Quality ($WSICRB_j$)

Id	Subbasin	CWQI		NFS	
		WQI	Quality	WQI	Quality
1	Jerry Creek - Colorado River	70.4	Fair	70.2	Good
2	Big Salt Wash - Colorado River	62.8	Marginal	62.8	Moderate
3	Sink Creek - Colorado River	73.0	Fair	72.8	Good
4	Outlet Gunnison River	70.3	Fair	70.0	Good

Source:

- National Sanitation Foundation (2020). Water Research Center: Monitoring the quality of surface waters
- Canter (1998). Transformation Functions for parameter expressed in Quality Index.
- NWQMC (2022). National Water Quality Monitoring Council: Water Quality Data.

Water Quality ($WSICRB_i$)



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Implementation of the WSICRB.

Accessibility ($WSICRB_k$)

Grand Junction Area

ACCESSIBILITY ($WSICRB_k$)

Subbasin			County		$WSICRB_k$				
Name	Area km²	%	Name	Area km²	TP-TotPop	PS-TOPop	WSUP	%	Degree
Jerry Creek - Colorado River*	765.09	8.84%	Mesa	8,653.34	148,513.00	144,180.00	0.971	87.49%	High
	148.52	1.94%	Garfield	7,655.50	58,095.00	45,250.00	0.779		
Big Salt Wash - Colorado River*	924.76	10.69%	Mesa	8,653.34	148,513.00	144,180.00	0.971	87.49%	High
	152.58	1.99%	Garfield	7,655.50	58,095.00	45,250.00	0.779		
Sink Creek - Colorado River	296.16	3.42%	Mesa	8,653.34	148,513.00	144,180.00	0.971	97.08%	Extremelly High
Outlet Gunnison River	269.39	3.11%	Mesa	8,653.34	148,513.00	144,180.00	0.971	97.08%	Extremelly High

* Avg. Between two conunties.

Source:

- Dieter et. al (2018): Estimated use of water in the United States county-level data for 2015 (ver. 2.0, June 2018).
- USGS (2015). The U.S. Geological Survey's National Water-Use Science Project (formerly the National Water-Use Information Program)

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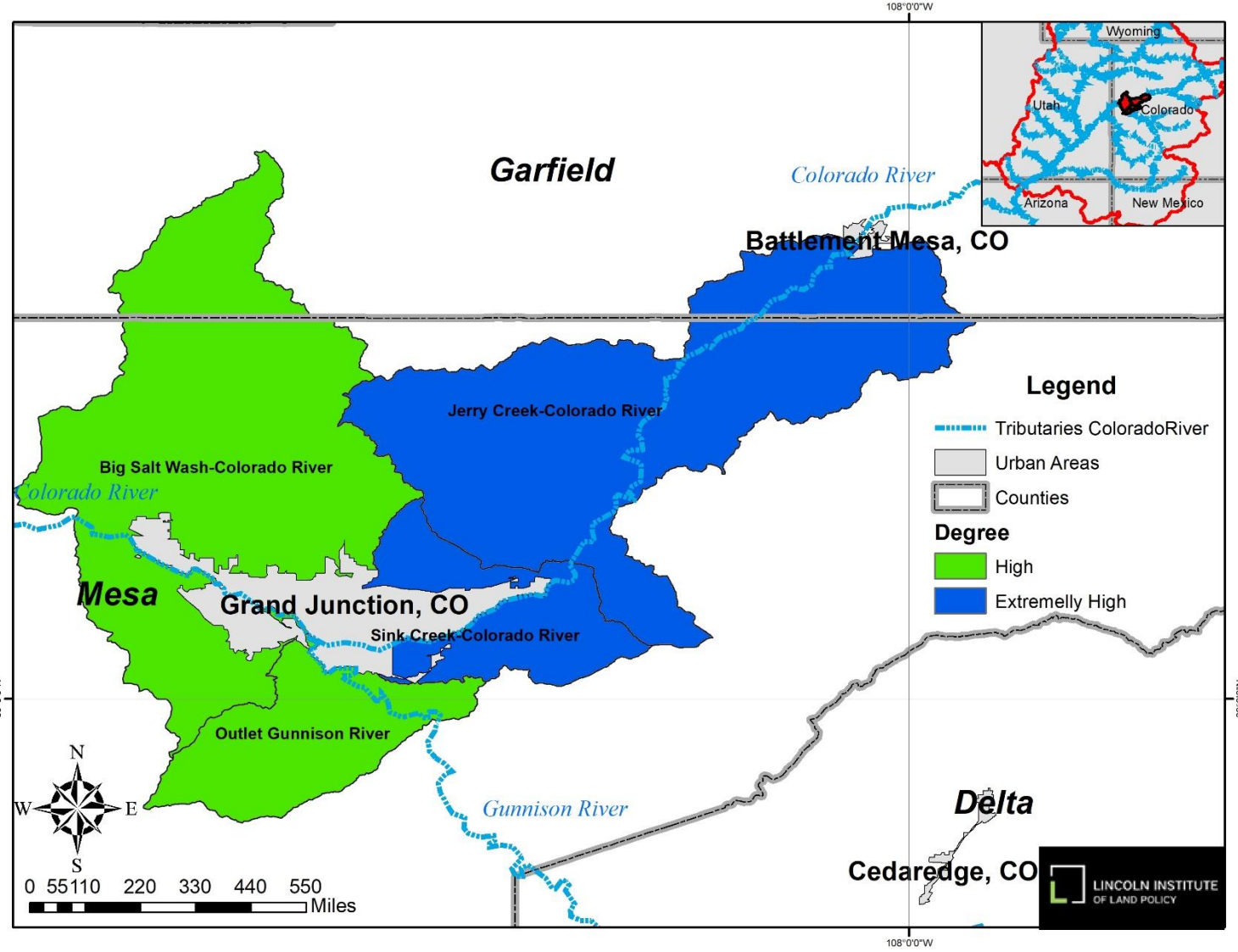
Accessibility ($WSICRB_k$)



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Implementation of the WSICRB

Potencial Risks ($WSICRB_I$)

Grand Junction Area

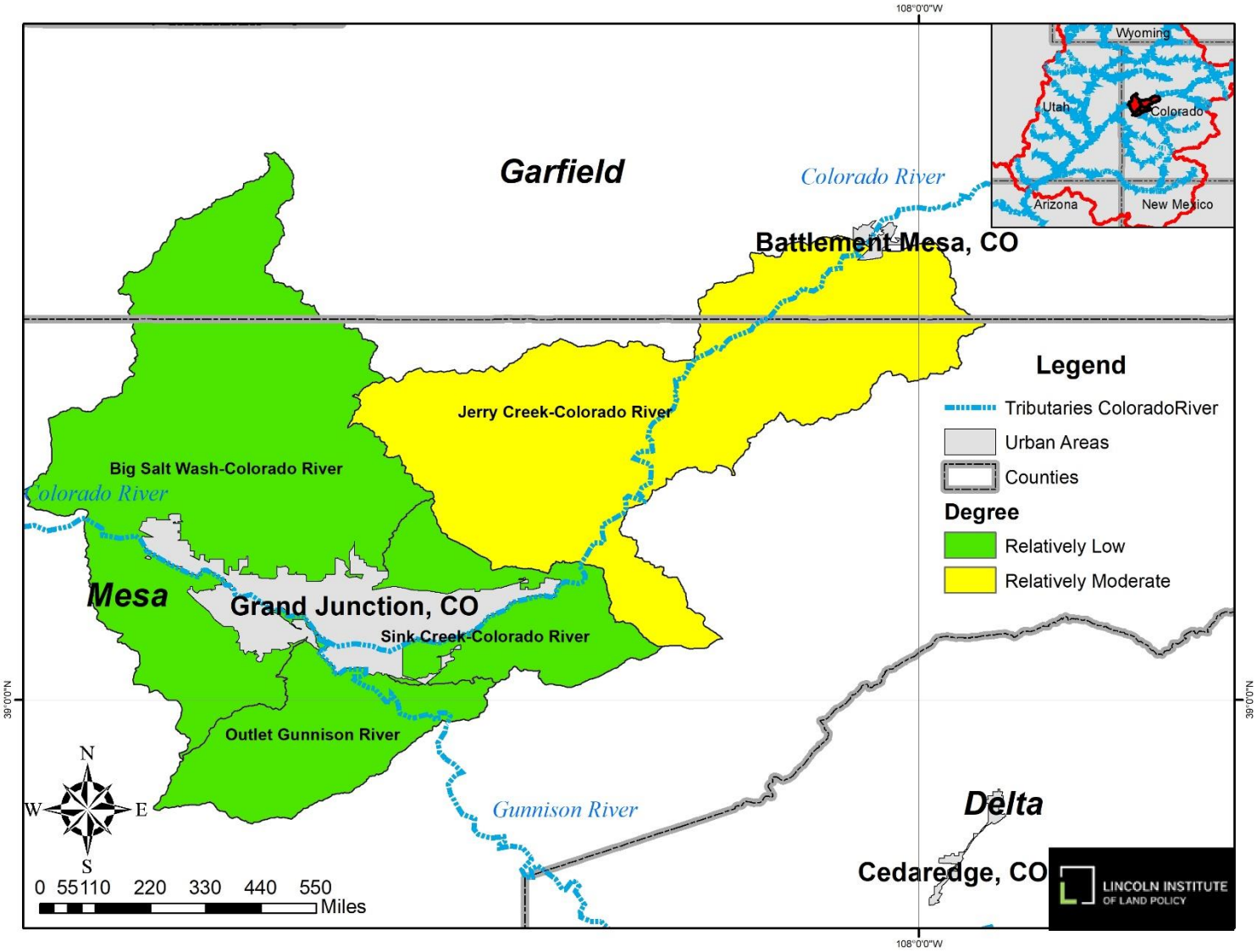
POTENCIAL RISK ($WSICRB_I$)

#	Subbasin		NRI | Score		$WSICRB_I$	
	Name	Area km^2	Score	Rating	Value	Degree
1	Jerry Creek - Colorado River	913.61	25.12	Relatively High	0.749	Relatively Moderate
2	Big Salt Wash - Colorado River	1,077.34	17.84	Relatively Low	0.822	Relatively Low
3	Sink Creek - Colorado River	296.16	15.29	Relatively Low	0.847	Relatively Low
4	Outlet Gunnison River	269.39	16.70	Relatively Low	0.833	Relatively Low

Source:

- FEMA (2021). National Risk Index
- FEMA (2022). National Risk Map (https://hazards.fema.gov/nri/map)

Potencial Risks (WSICRB$_I$)



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WSICRB

Grand Junction Area

WATER SECURITY INDEX IN THE COLORADO RIVER BASIN (WSICRB)

#	Subbasin	$WSICRB_i$	Degree	$WSICRB_j$	Degree	$WSICRB_k$	Degree	$WSICRB_l$	Degree	WSICRB	Degree
1	Jerry Creek - Colorado River	0.294	Low	0.702	Good	0.875	High	0.749	Relatively Moderate	0.606	Low
2	Big Salt Wash - Colorado River	0.260	Low	0.628	Moderate	0.875	High	0.822	Relatively Low	0.585	Low
3	Sink Creek - Colorado River	0.142	Very Low	0.728	Good	0.971	Extremelly High	0.847	Relatively Low	0.540	Low
4	Outlet Gunnison River	0.094	Very Low	0.700	Good	0.971	Extremelly High	0.833	Relatively Low	0.481	Very Low
	Avg.	0.198	Very Low	0.689	Moderate	0.923	High	0.813	Relatively Low	0.565	Low

WSICRB

Degree	Value
Extremelly High	*WSICRB* > 0.91
High	0.81 < WSICRB <= 0.90
Moderate	0.71 < WSICRB <= 0.80
Low	0.51 < WSICRB <= 0.70
Very Low	0.31 < WSICRB <= 0.50
Extremely Low	*WSICRB* < 0.30

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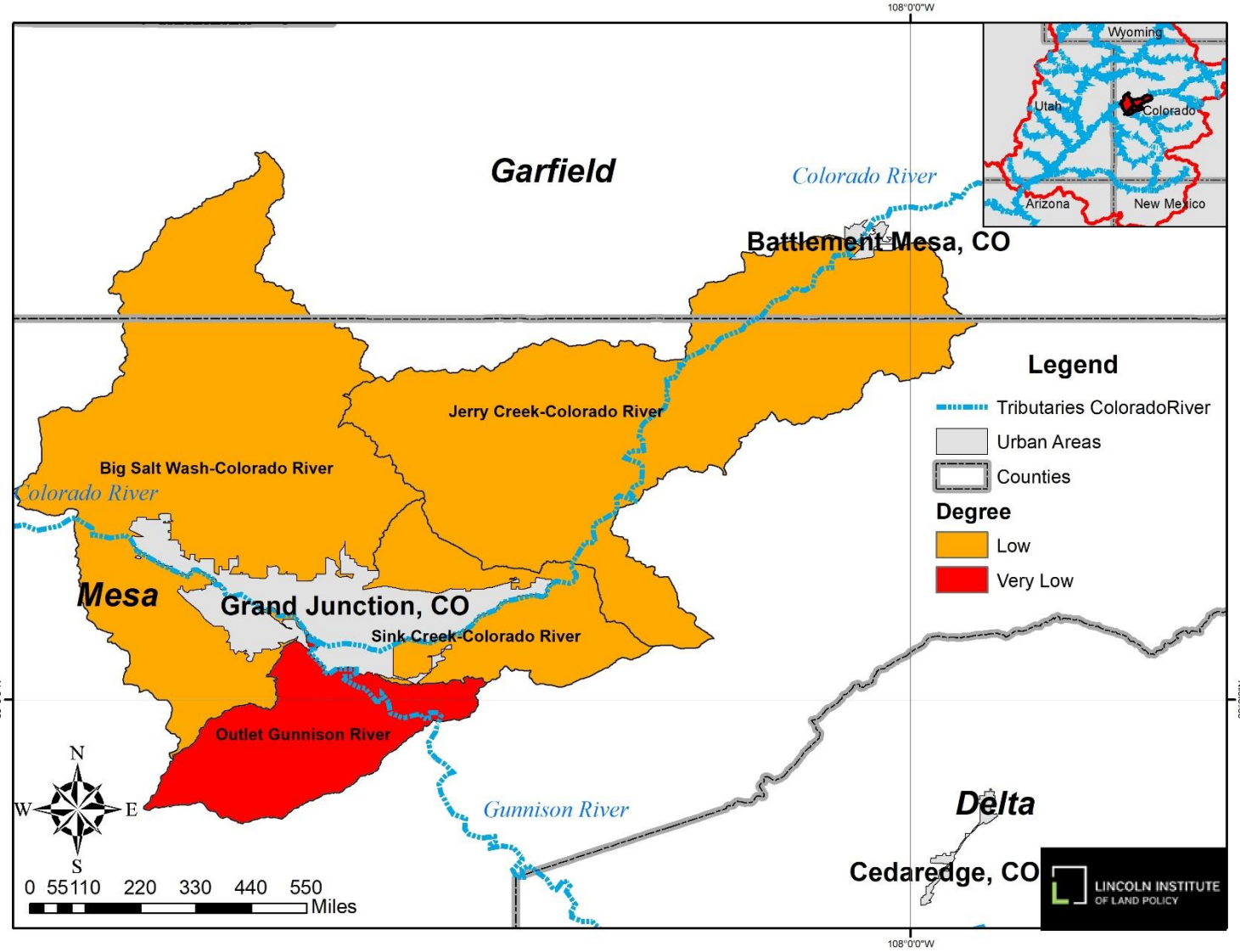
Implementation of the WSICRB.



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Information limitations and Results interpretation challenges.

The most relevant challenges in any study region where the WSICRB was implemented have to do with the information for the estimation of values necessary to calculate each component, of which stand out: Annual Water Demand, Annual Water Availability, Water Quality information, Available Information from Users with potable water supply.

The challenges of interpreting comparative WSICRB results from one region to another are many. the most convenient way to compare results and make it an appropriate exercise, could only be done in those regions that have the same number of components and the same components, this with the aim of being objective in the detailed discussion.

Conclusions of the Proposal and development of the WSICRB

- ✓ The WSICRB was designed, proposed, and implemented in Grand Junction, Colorado which are in Upper Colorado basin.
- ✓ The methodology for the construction of the WSICRB evaluated and used available official information.
- ✓ The water resource is quantified under a hydrological approach.
- ✓ The proposed index is designed to evaluate at least **three indicators** and there is **no maximum number of indicators** that can be added.
- ✓ The WSICRB can be **replicated in any of the country's watersheds**, at **any level**, even with **different indicators** in each region
- ✓ Partial preliminary results show that in the Grand Junction region, there is "*Low Water Security*" with a WSICRB value of 0.565.
- ✓ The WSICRB proposed in this research project is an initial attempt to quantify water security by hydrological basin in the Colorado River basin.

CONTACT

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