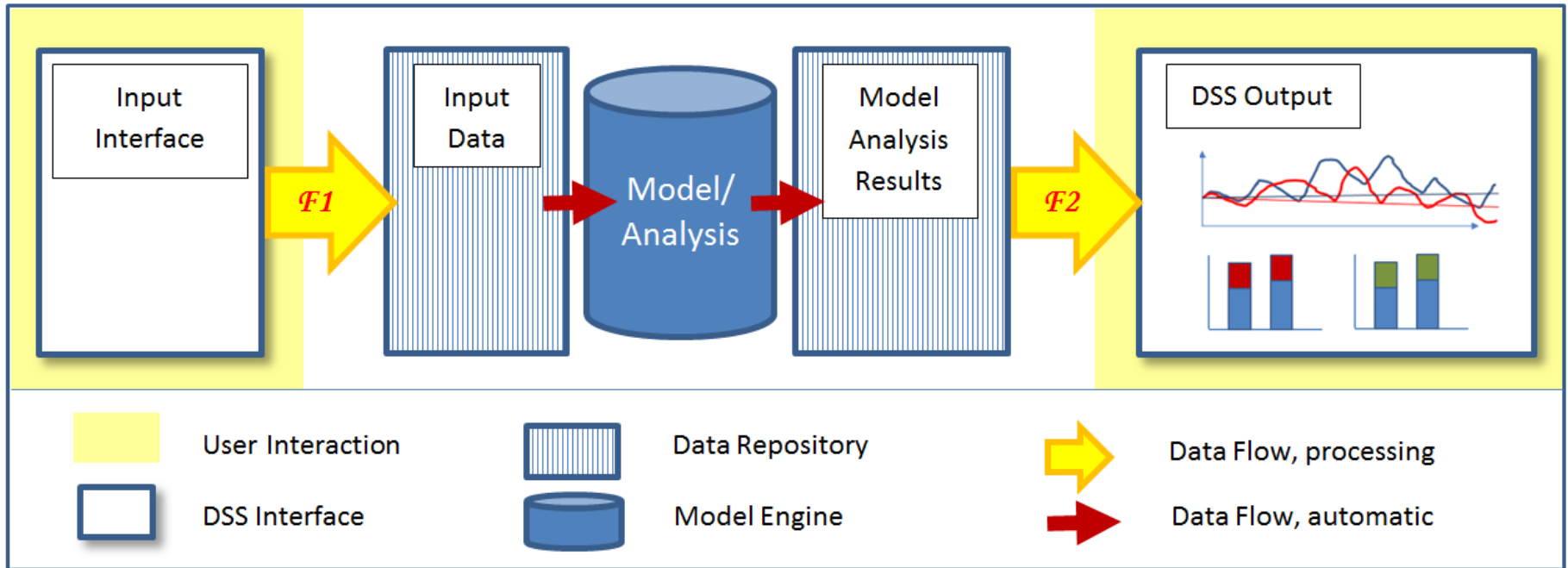


A FRAMEWORK FOR ASSESSING WATER USE SUSTAINABILITY IN RIVER BASINS

Carter Borden, Peter Goodwin
University of Idaho, Dept. of Civil Engineering
HP 3 Meeting, Delhi. – February 4, 2015

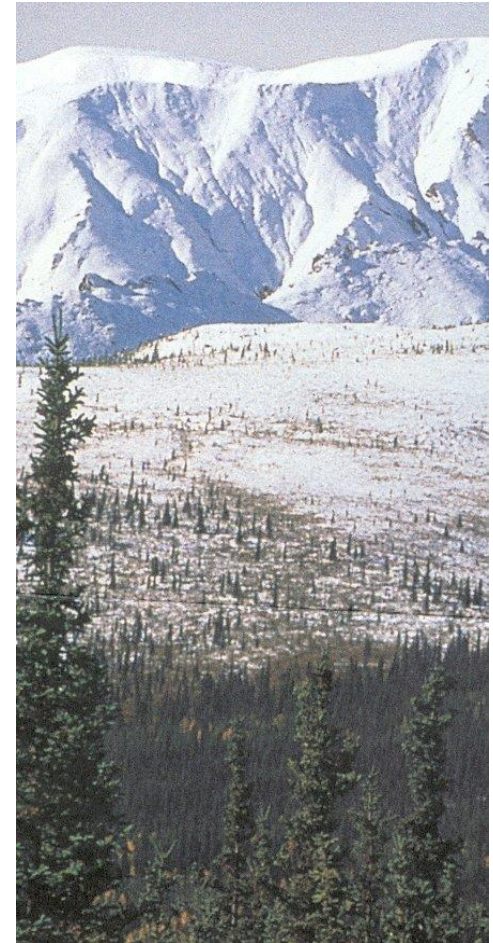
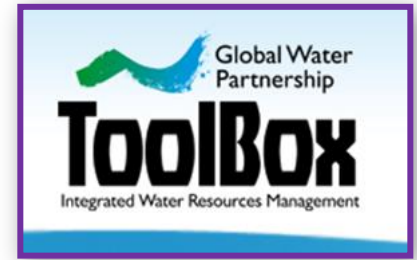


Using Data to Make a Decision



IWRM Definition

*“a process which promotes the coordinated development and management of water, land and related resources in order to maximise the resultant **economic and social welfare** in an equitable manner without compromising the **sustainability of vital eco-systems**”*



Source: GWP , 2004

Water Influence

Social



Hydrology

Ecology



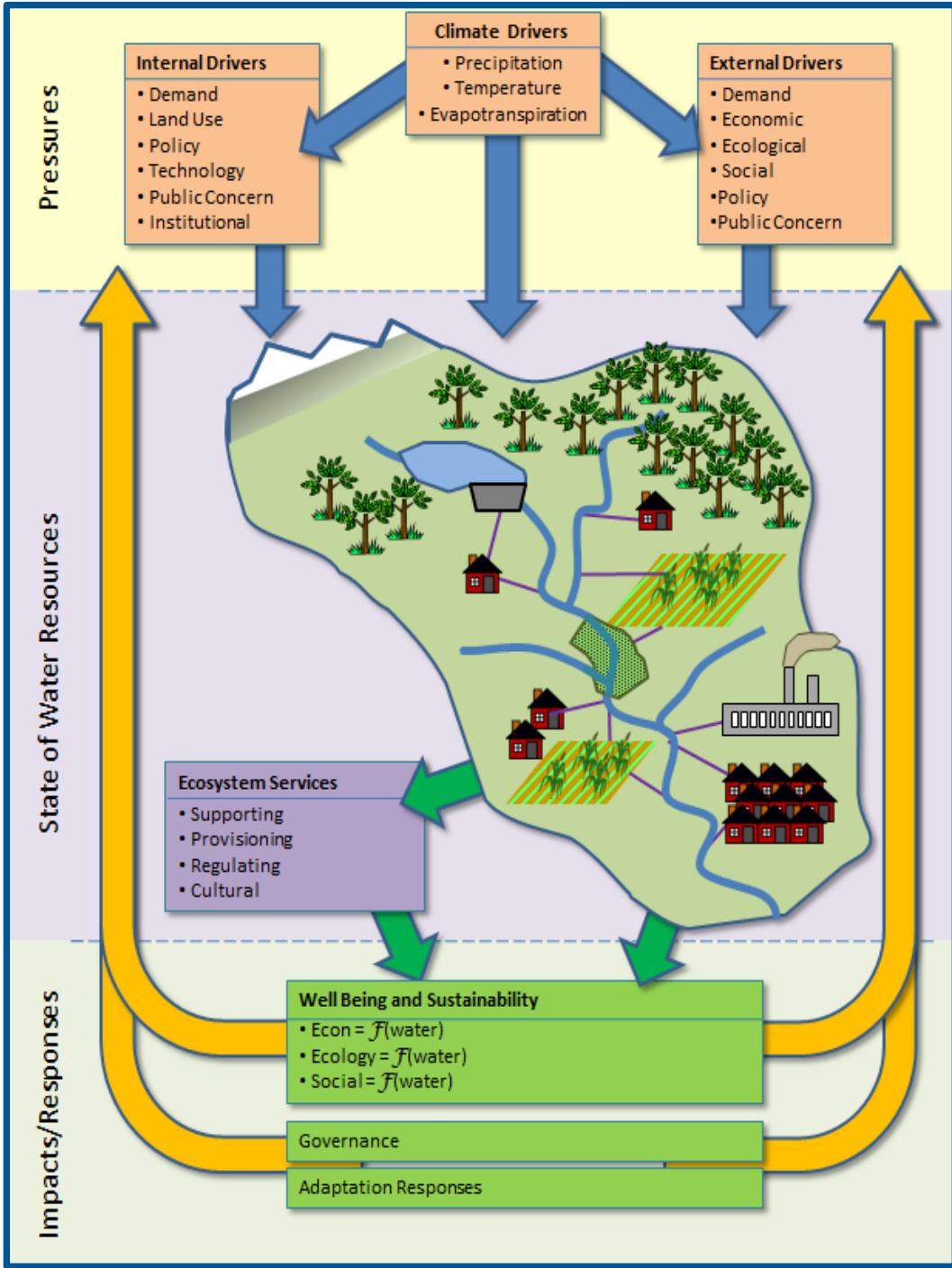
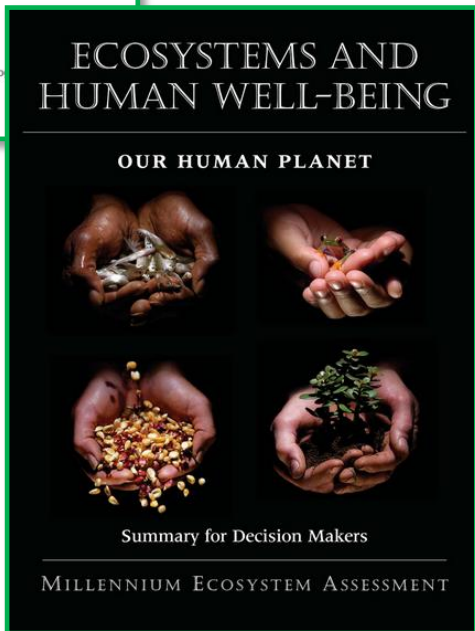
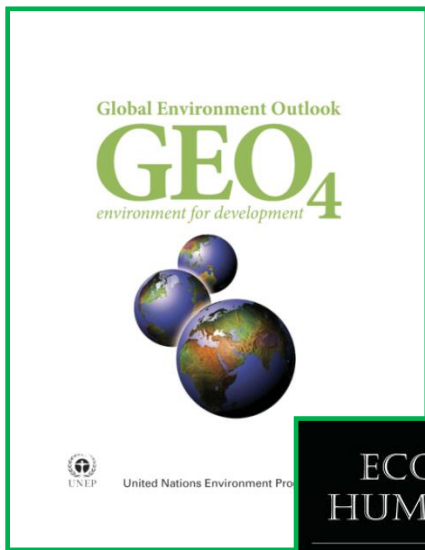
Economy



Sustainability Assessments

- Multi-stakeholder perspectives
- Multi-disciplinary: ecology, economic, social
 - Systems operate on different spatiotemporal scales
 - Complex interactions
 - Inherent socio-economic and ecologic capacities
- Intra- and inter-generational linkages
- Support Adaptive Management
- Uncertain future: moving target
- Knowledge and resources limited

Conceptual Basis



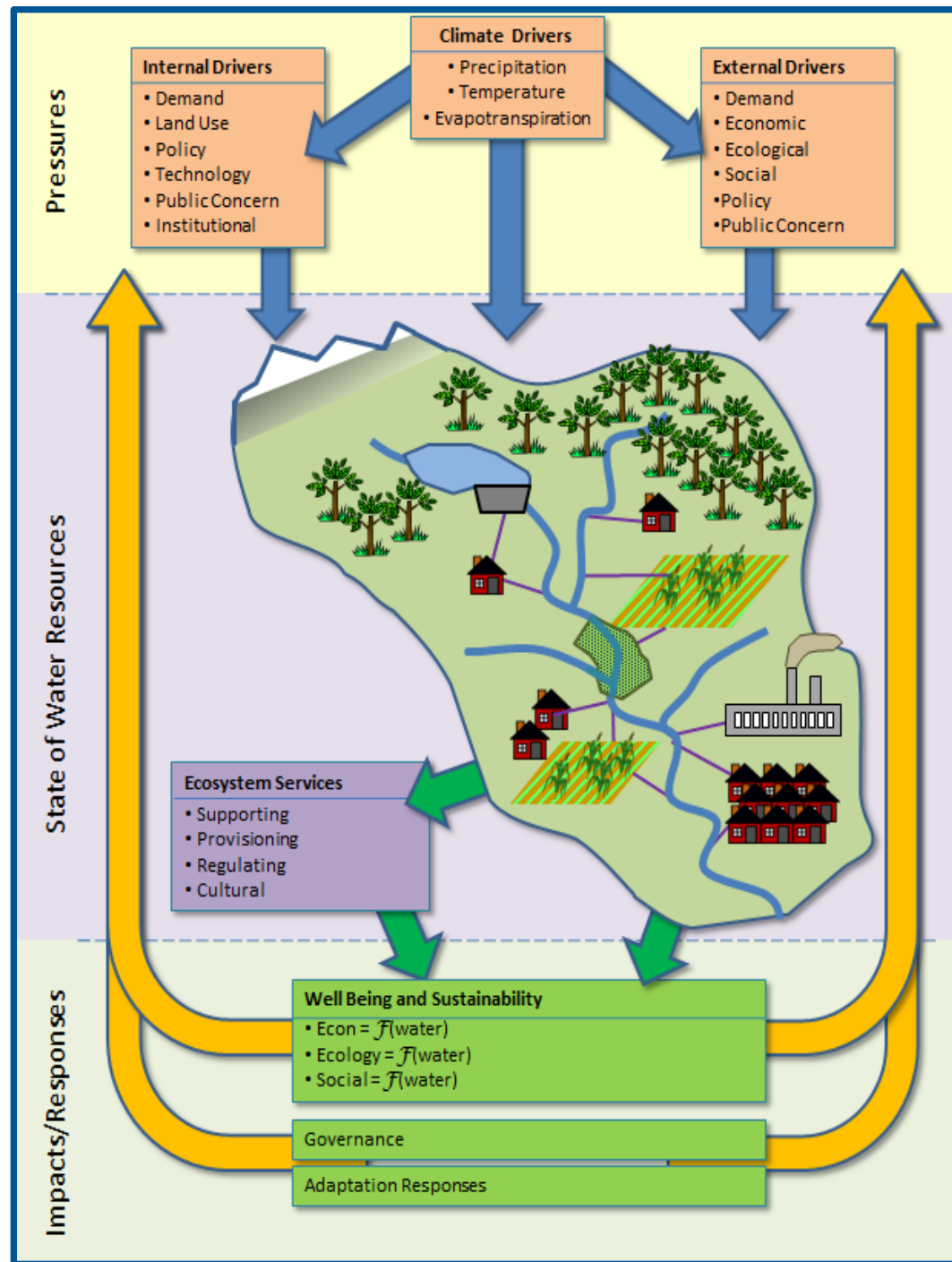


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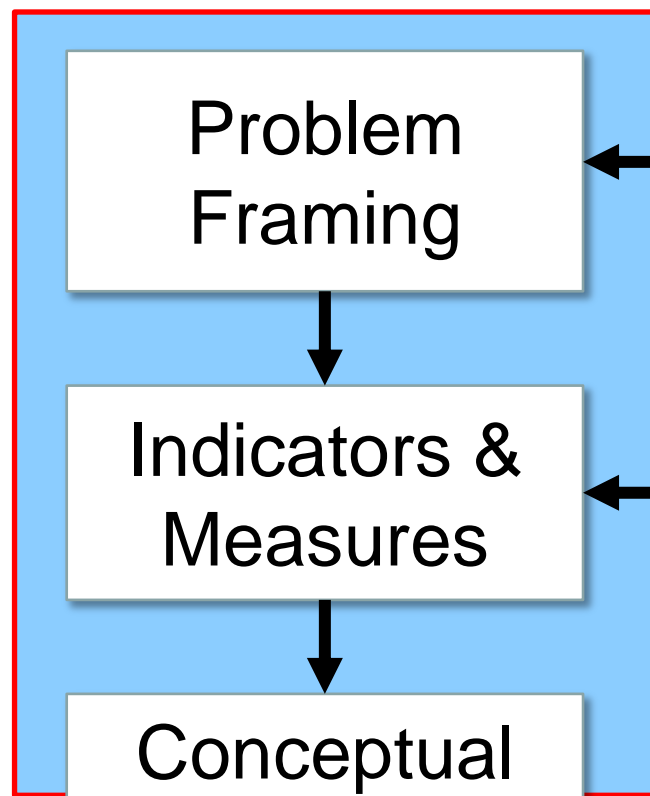
RBAF Objectives

- Participatory setting
- Systematic checklist in formulating conceptual model
- Positions the environment
- Organize analysis results of the SC
- Supports IWRM
- Communication tool
- Flexible/transferrable



IWRM: Analysis Support

RBAF-CT



Conceptual
Framework

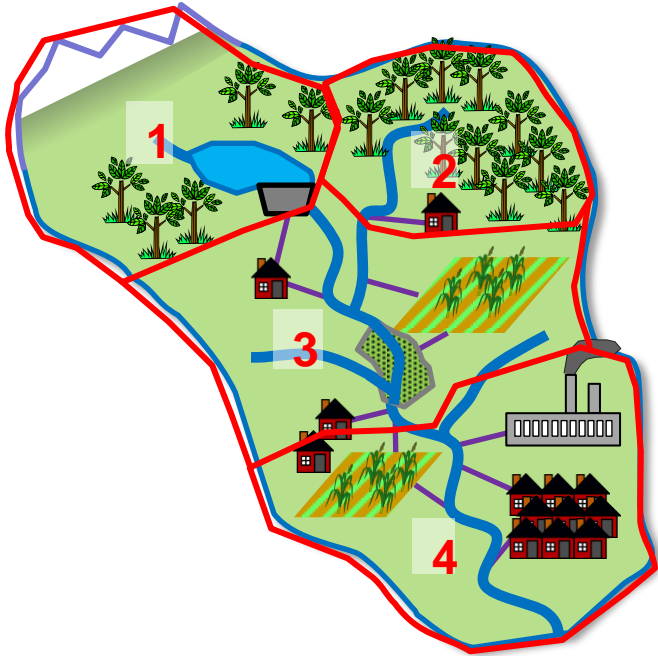
Analysis

RBAF-AI



Decision
Making

Source: Giupponi
et al. 2005



<i>Habitat</i>	<i>Sections</i>			
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>
River	Green	Green	Green	Green
Floodplains	Green	Green	Green	Green
Snowpack	Green	Green	Green	Green
Wetlands	Green	Green	Green	Green
Reservoir	Green	Green	Green	Green

	<i>Section 1</i>			
<i>Riverine</i>	Hydrologic Indicators	EGS Impact Description & Relevant Indicators	Impact of Relevant HWB Categories	HWB Impact Description & Relevant Indicators
<i>Relevant</i>				
<i>EGS</i>				
<i>Floodplain</i>				



Driver Templates

- Climate
- Demand
- Supply
- Infrastructure
- Landuse
- Economic
- Ecological
- Societal Preference
- Institutional

Baseline

Unaltered System

Current

Scenario 1

Population/

Industrial Increase

Short-Term

Scenario 2

Population/

Industrial Increase

Long-Term

Scenario 3

Climate Change

Long-Term

<i>Habitat</i>	<i>Sections</i>			
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>
River	Unaltered	Unaltered	Unaltered	Unaltered
Floodplains	Unaltered	Unaltered	Unaltered	Unaltered
Snowpack	Unaltered	Unaltered	Unaltered	Unaltered
Wetlands	Unaltered	Unaltered	Unaltered	Unaltered
Reservoir	Unaltered	Unaltered	Unaltered	Unaltered
River	Unaltered	Altered	Active	Active
Floodplains	Unaltered	Unaltered	Active	Active
Snowpack	Unaltered	Unaltered	Unaltered	Unaltered
Wetlands	Unaltered	Unaltered	Active	Unaltered
Reservoir	Altered	Unaltered	Unaltered	Unaltered
River	Active	Active	Active	Active
Floodplains	Altered	Unaltered	Altered	Altered
Snowpack	Active	Unaltered	Unaltered	Unaltered
Wetlands	Unaltered	Unaltered	Active	Unaltered
Reservoir	Active	Unaltered	Unaltered	Unaltered

Unaltered



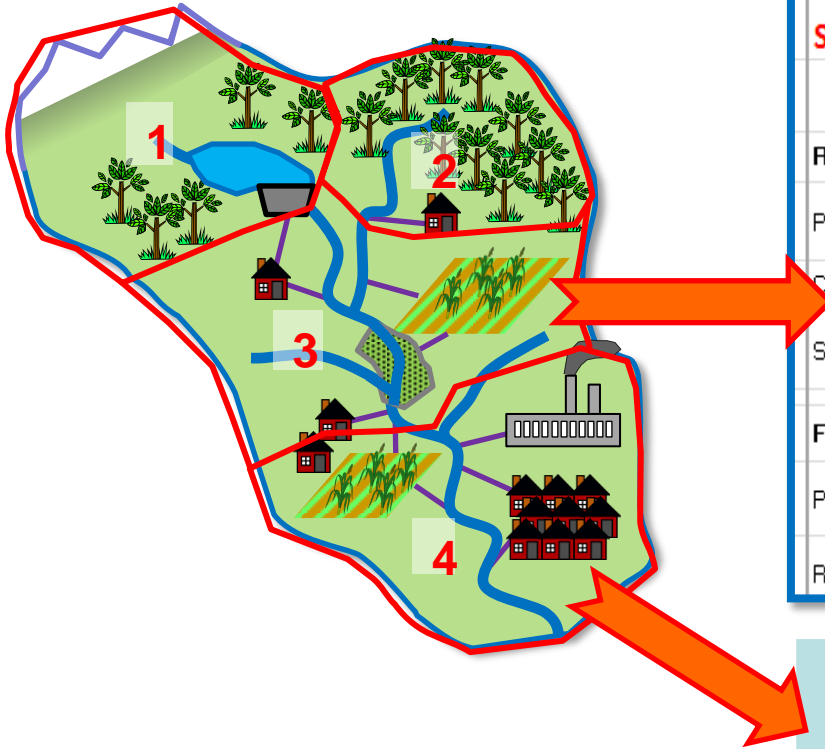
Altered



Active



RBAF-CT Products

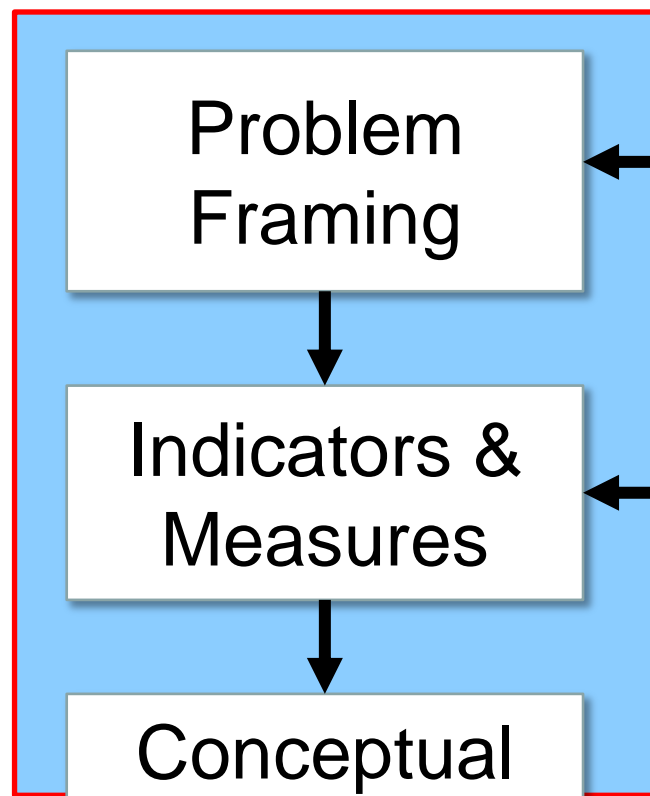


Section 4		EGS Trend					HWB Trend			
Habitat	EGS Categories	B	S1	S2	S3		B	S1	S2	S3
Riverine		-	↕	↕	↓	5,X	-	↗	↑	↓
Provisioning	Freshwater Consumption, Production	-	↗	↑	↓	5,X	-	↗	↑	↓
Cultural	Aesthetic, Recreation	-	↑	↔	↓	X	-	↔	↔	↓
Supporting	Hydrologic & Nutrient Cycle, Habitat, Biodiversity	-	↕	↕	↓	5,X	-	↔	↔	↓
Floodplain		-	↕	↕	↓	5,X	-	↕	↕	↓
Provisioning	Freshwater Consumption, Production	-	↕	↕	↓	5,X	-	↕	↕	↓
Regulating	Water Regulation, Storm Protection	-	↔	↔	↓	5,X	-	↔	↔	↓

	Hydrology	Ecology	Economic	Social
Pressure				
State	Indicators			
Impact				

IWRM: Analysis Support

RBAF-CT



Conceptual
Framework

Analysis

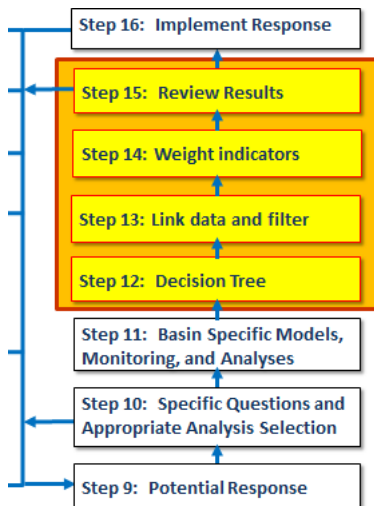
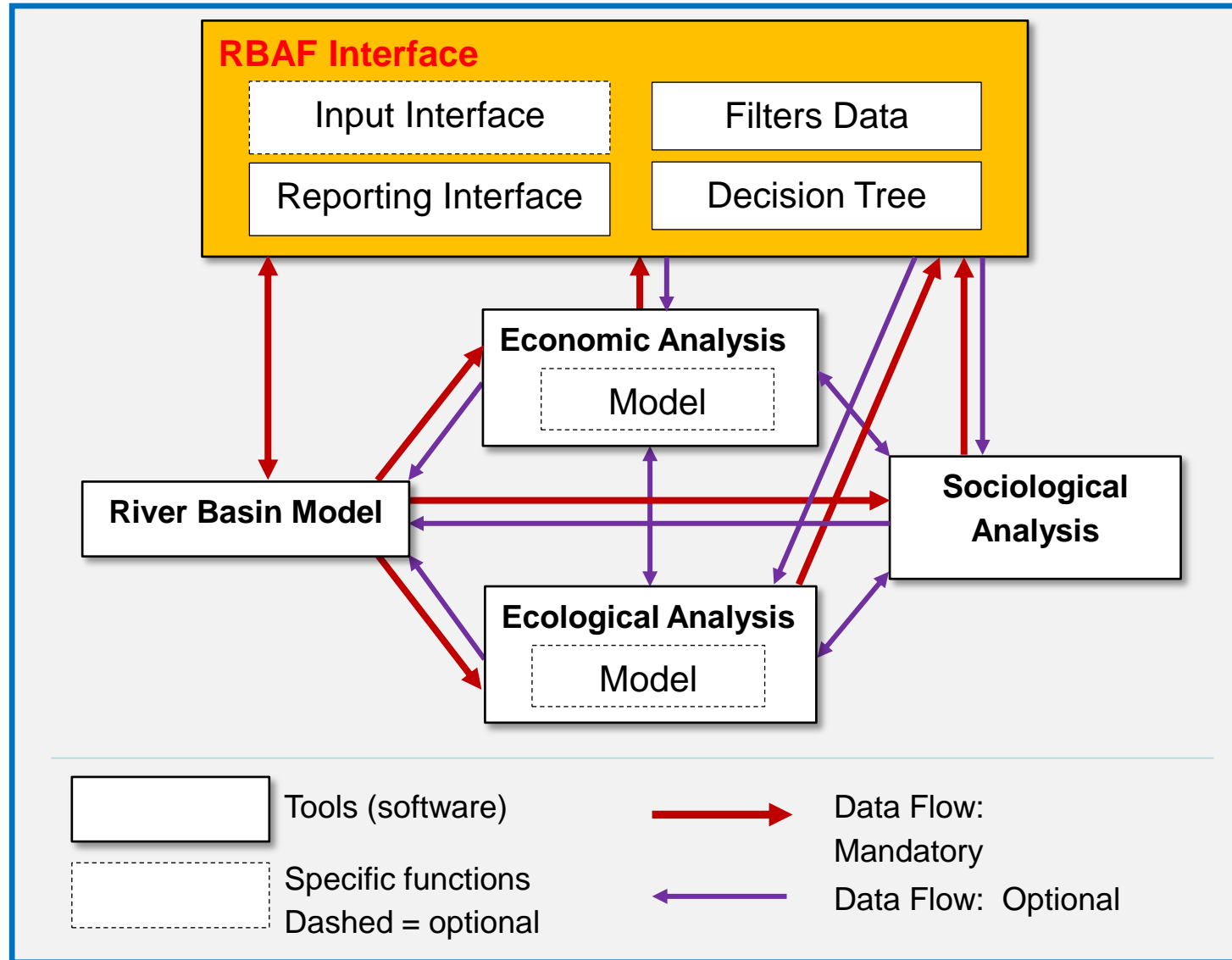
RBAF-AI



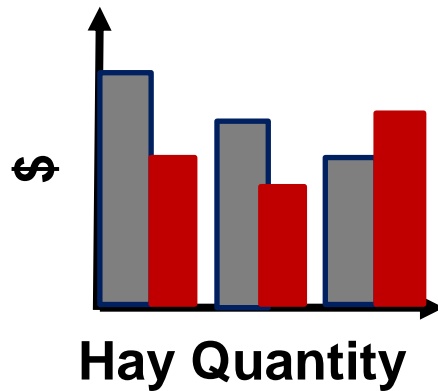
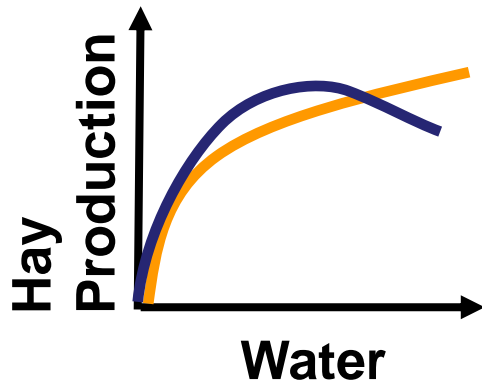
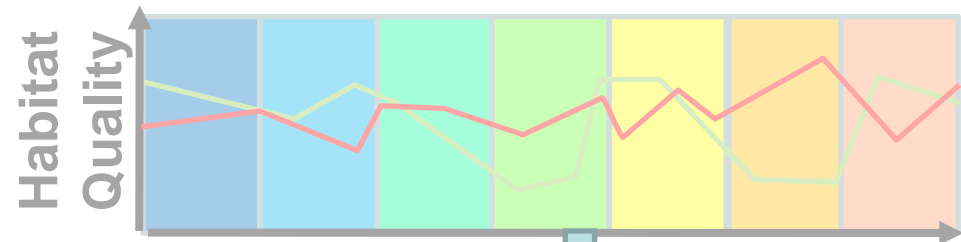
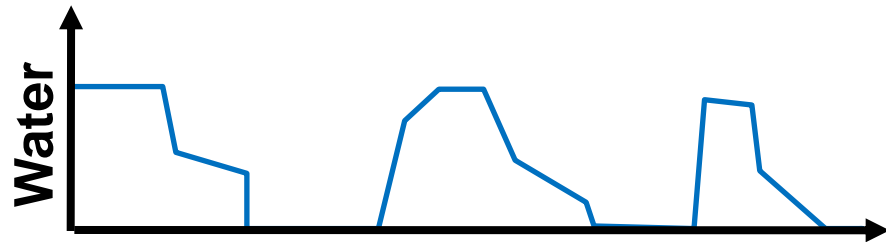
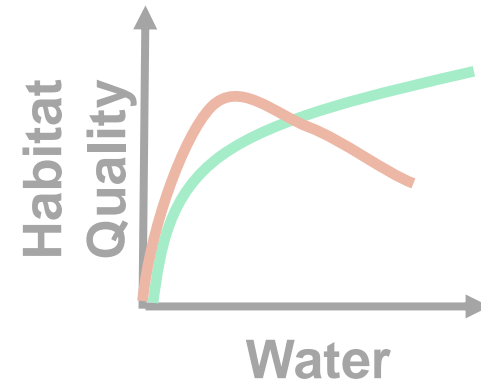
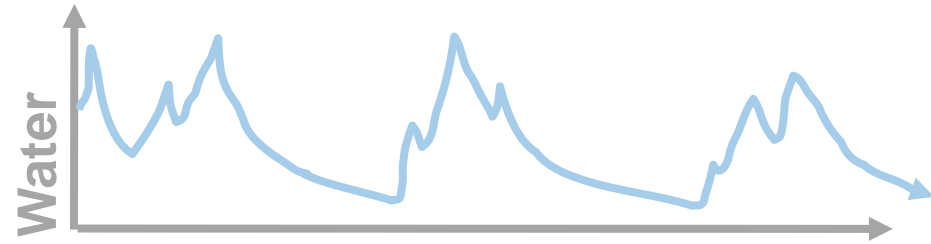
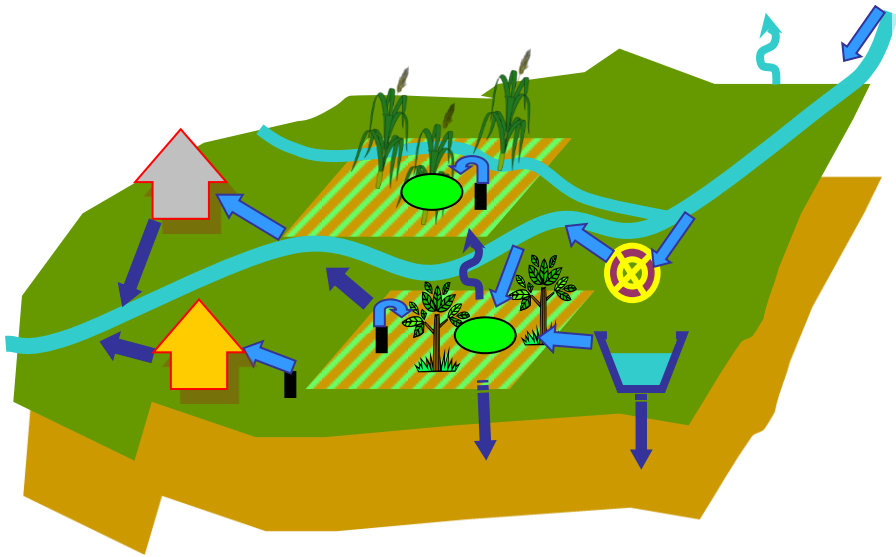
Decision
Making

Source: Giupponi
et al. 2005

RBAF-AI



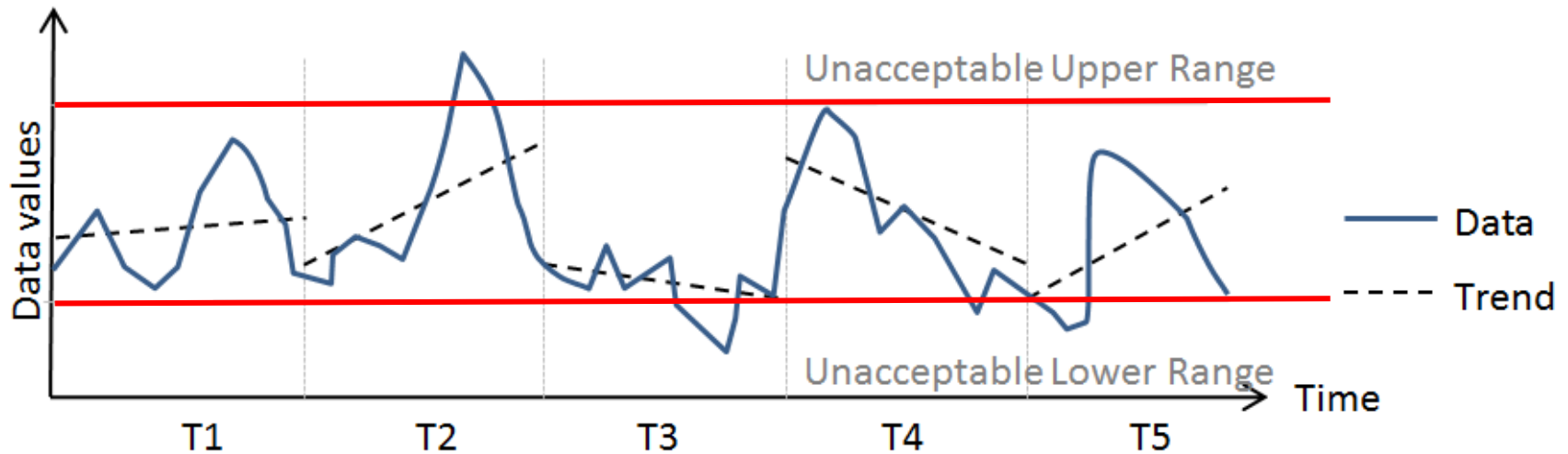
Data Flow



Ecological Score

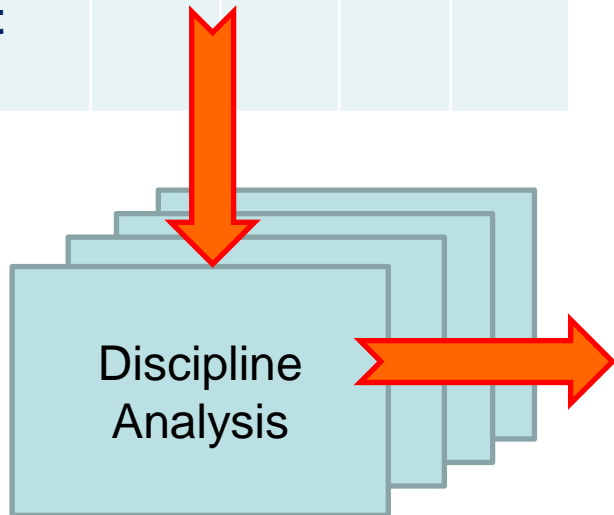
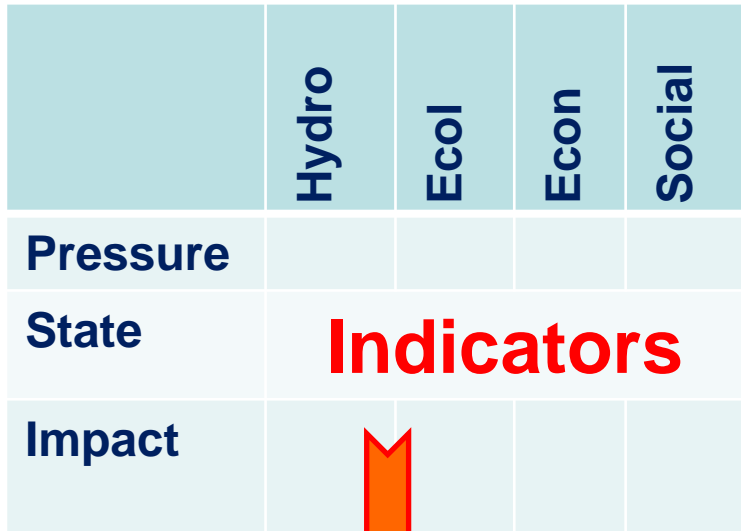
Economic Score

Filters



Filter	Equation	Source
Trend	$= \Delta D / \Delta t$	1
Reliability	$= \Sigma \# D_A / \Sigma \# D$ where $D_A = T_L < D < T_U$	1
Resilience	$= \Sigma \# C / \Sigma \# D_U$ where $C = 1$ when $D_{U t}, D_{A t+1}$	1
Vulnerability	$= (\Sigma D_U / \# D_U) / \Sigma D_T$	3

RBAF-AI



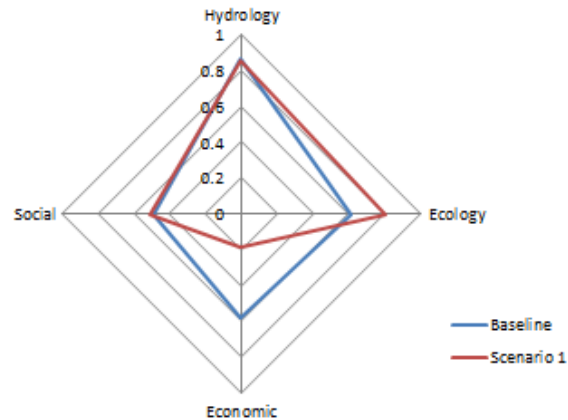
RBAF-AI
Output

Simulation Information

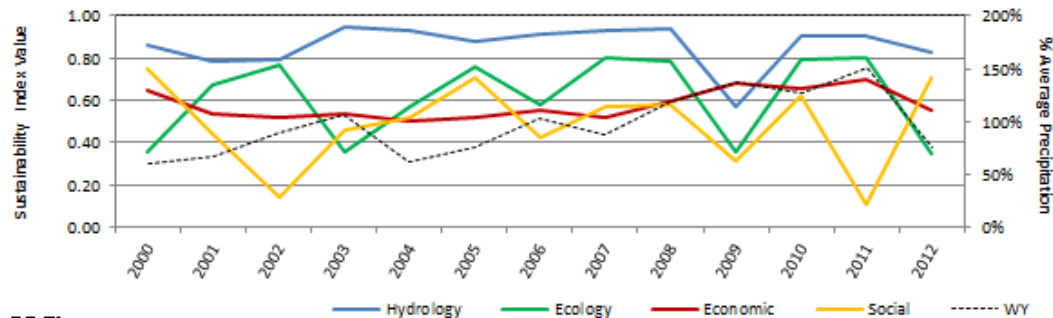
Baseline Current Status
Scen. 1 Policy 45
Decision Tree H1 EC1 EN3 S1

Radar Plot

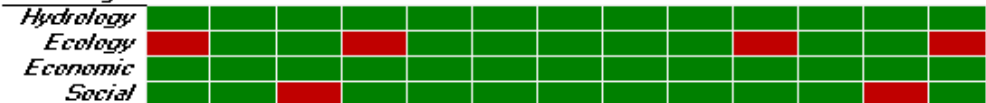
	Baseline		Scenario 1	
	SI	SS	SI	SS
<i>Hydrology</i>	0.861	Green	0.852	Green
<i>Ecology</i>	0.610	Red	0.807	Green
<i>Economic</i>	0.579	Green	0.183	Red
<i>Social</i>	0.488	Green	0.512	Green



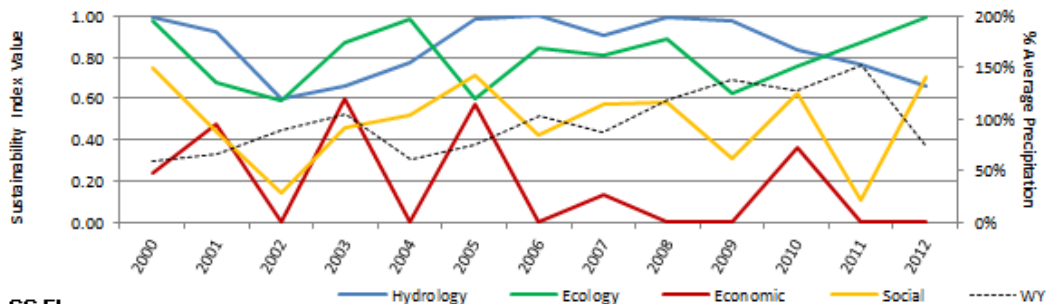
Baseline



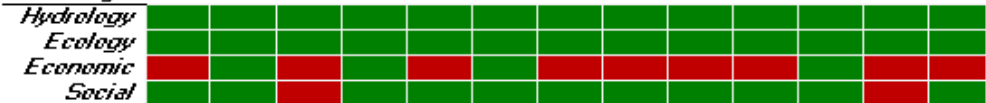
SS Flag



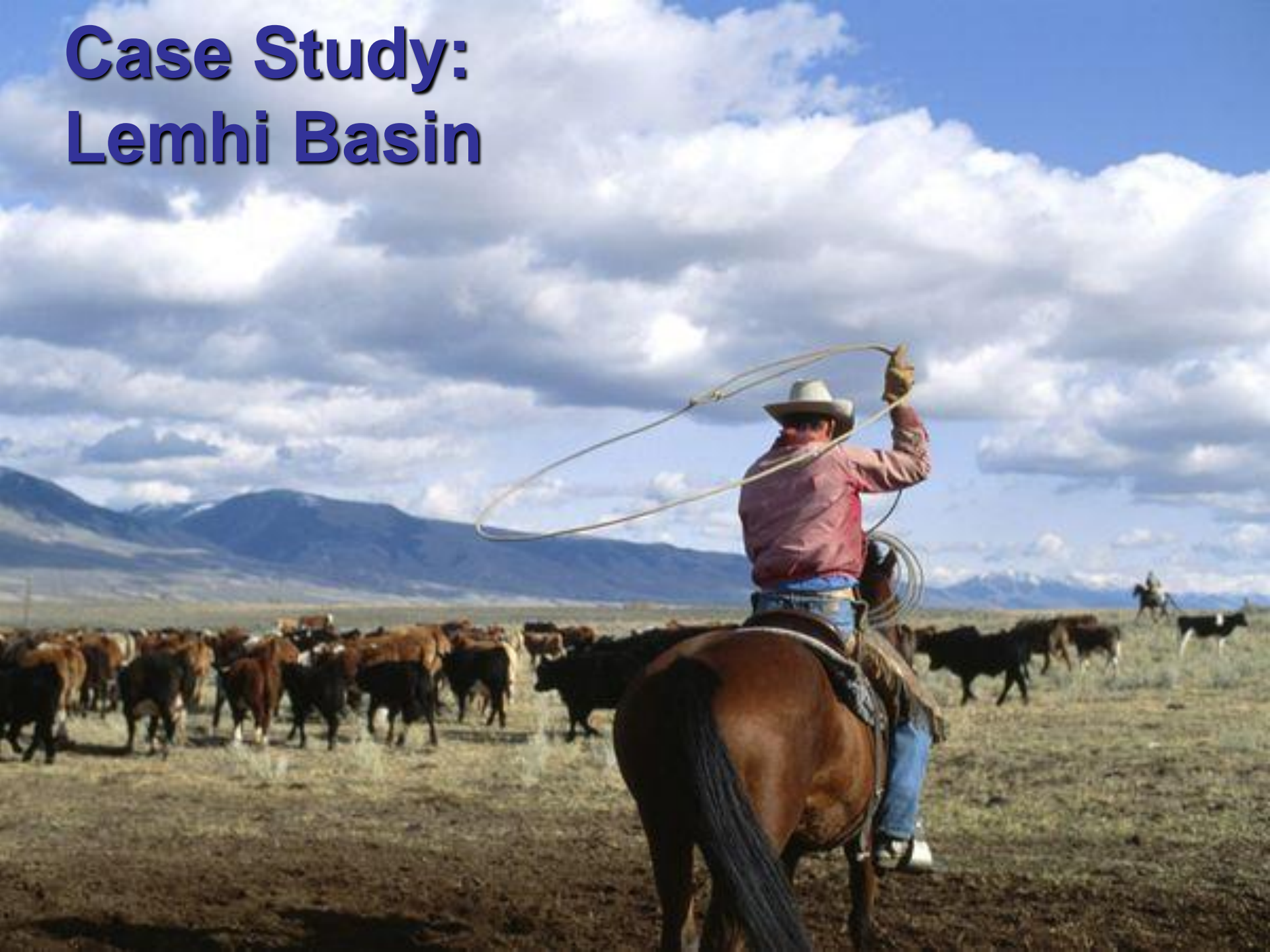
Scenario 1

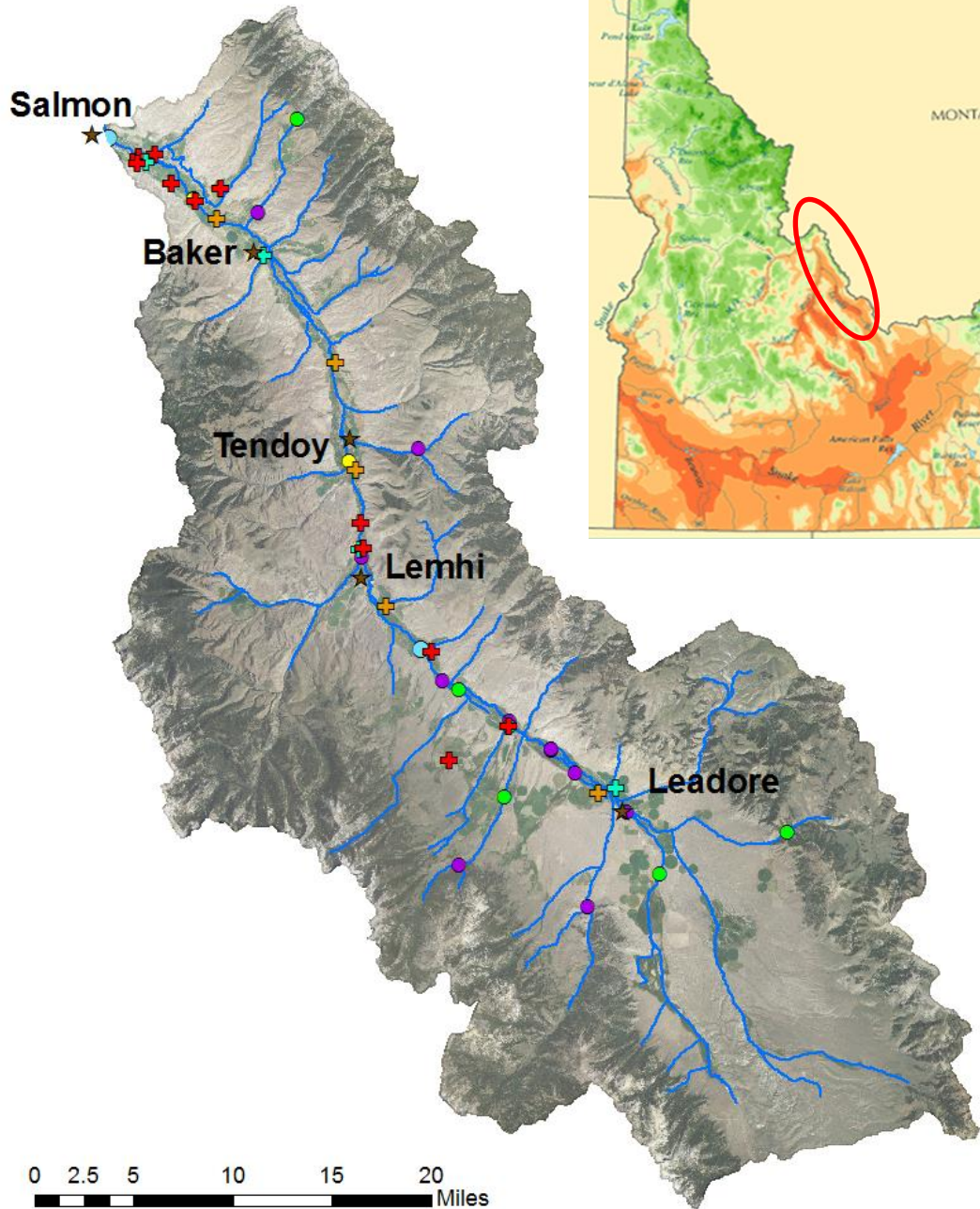


SS Flag



Case Study: Lemhi Basin





Photos by Taylor Dixon, IDWR



Leadore, ID



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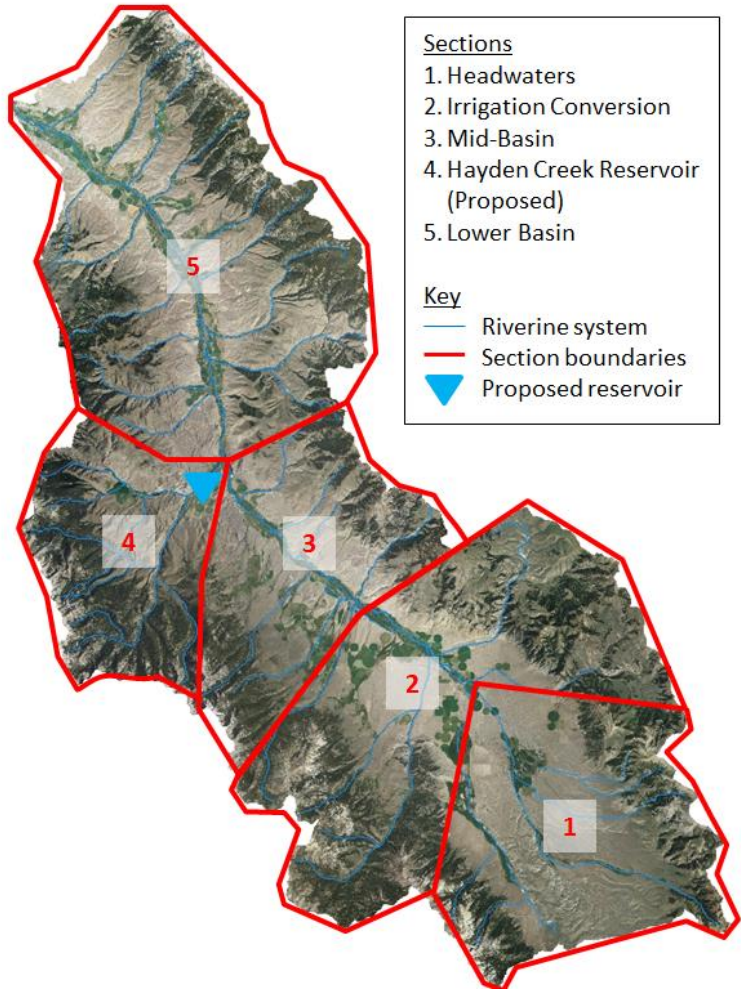
USDA Farm Service Agency
Image © 2013 TerraMetrics

Google

44° 43' 11.18" N 113° 08' 49.00" W elev 7889 ft

Eye alt

RBAF-CT: LRB



Baseline
Unaltered
 System
 Current

Habitat	1	2	3	4	5
Snowpack	Unaltered	Unaltered	Unaltered	Unaltered	Unaltered
River	Unaltered	Unaltered	Unaltered	Unaltered	Unaltered
Floodplain	Unaltered	Unaltered	Unaltered	Unaltered	Unaltered
Lake	Unaltered	Unaltered	Unaltered	Unaltered	Unaltered
Wetland	Unaltered	Unaltered	Unaltered	Unaltered	Unaltered

Scenario 1
Conversion to
 sprinkler
 Short-Term

Snowpack	Unaltered	Unaltered	Unaltered	Unaltered	Unaltered
River	Unaltered	Active	Altered	Unaltered	Altered
Floodplain	Unaltered	Active	Altered	Unaltered	Altered
Lake	Unaltered	Unaltered	Unaltered	Unaltered	Unaltered
Wetland	Unaltered	Unaltered	Altered	Unaltered	Unaltered

Scenario 2
Conversion to
 sprinkler
 Long-Term

Snowpack	Unaltered	Unaltered	Unaltered	Unaltered	Unaltered
River	Unaltered	Active	Altered	Unaltered	Altered
Floodplain	Unaltered	Active	Altered	Unaltered	Altered
Lake	Unaltered	Unaltered	Unaltered	Unaltered	Unaltered
Wetland	Unaltered	Unaltered	Altered	Unaltered	Unaltered

Scenario 3
Reservoir
 Construction
 Medium-Term

Snowpack	Unaltered	Unaltered	Unaltered	Unaltered	Unaltered
River	Unaltered	Unaltered	Unaltered	Unaltered	Altered
Floodplain	Unaltered	Unaltered	Unaltered	Unaltered	Altered
Lake	Unaltered	Unaltered	Unaltered	Active	Unaltered
Wetland	Unaltered	Unaltered	Unaltered	Unaltered	Unaltered

Unaltered Altered Active

LRB Indicators: Irrigation

Hydrologic

- **Pressure:**
 - Change water demand
- **State**
 - Water flows
 - Water delivery
 - Irrigated area
 - Consumptive use
- **Impacts**
 - Reliability-delivery,
 - River flow: indices of alteration

Economic

- **Pressure:**
 - Irrigation change
 - Subsidies
- **State**
 - Crop production
 - Irrigated area
 - Net Income
 - Recreation dollars
- **Impacts**
 - Trend in net revenues agriculture, land under production
 - Trend in Recreation dollars

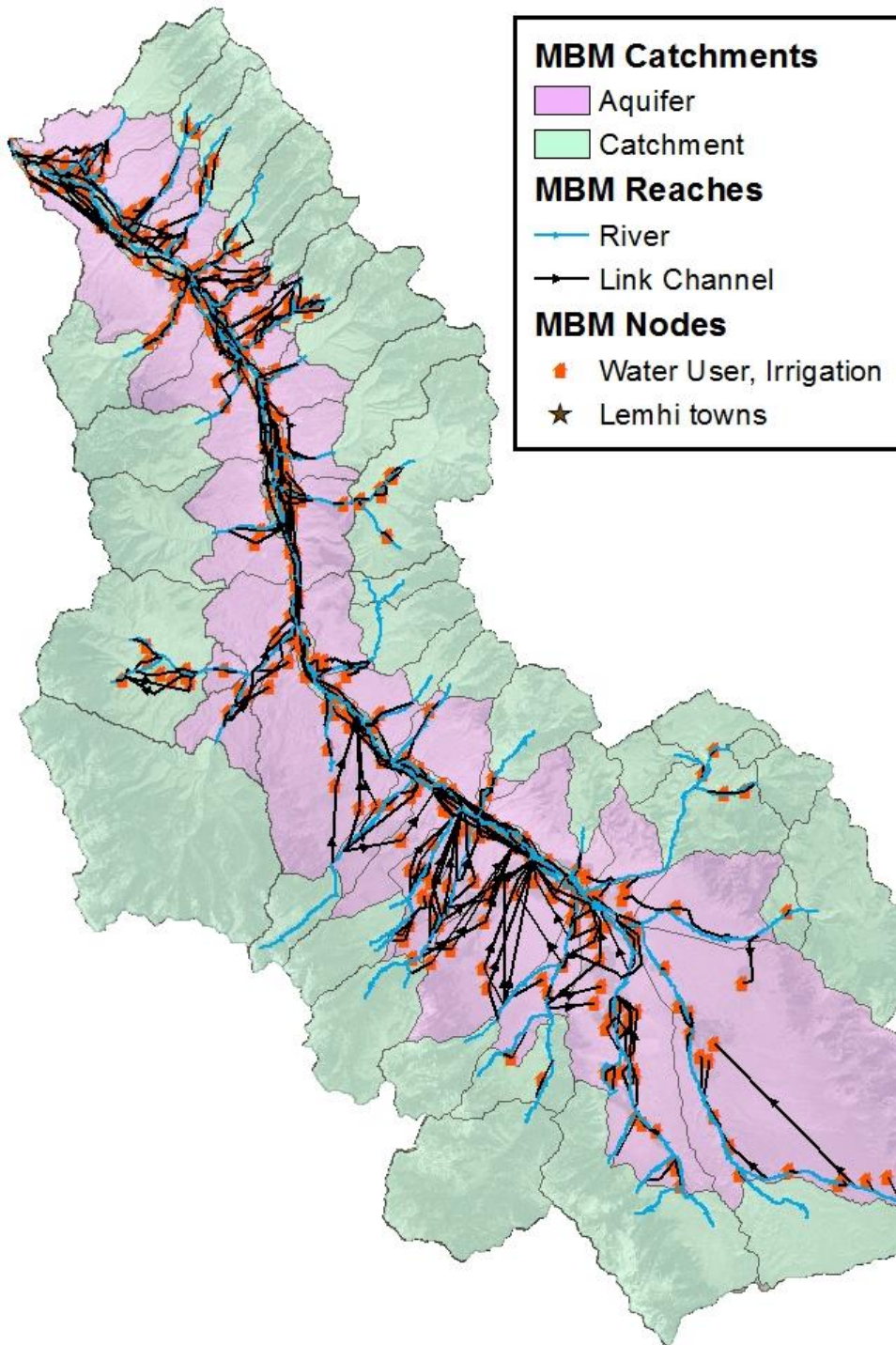
LRB Indicators: Irrigation

Ecologic

- **Pressure:**
 - None
- **State**
 - Species Habitat
 - Steelhead
 - Chinook salmon
 - Bull trout
 - Connectivity
- **Impacts**
 - Habitat quality
 - Change in # of migration barriers

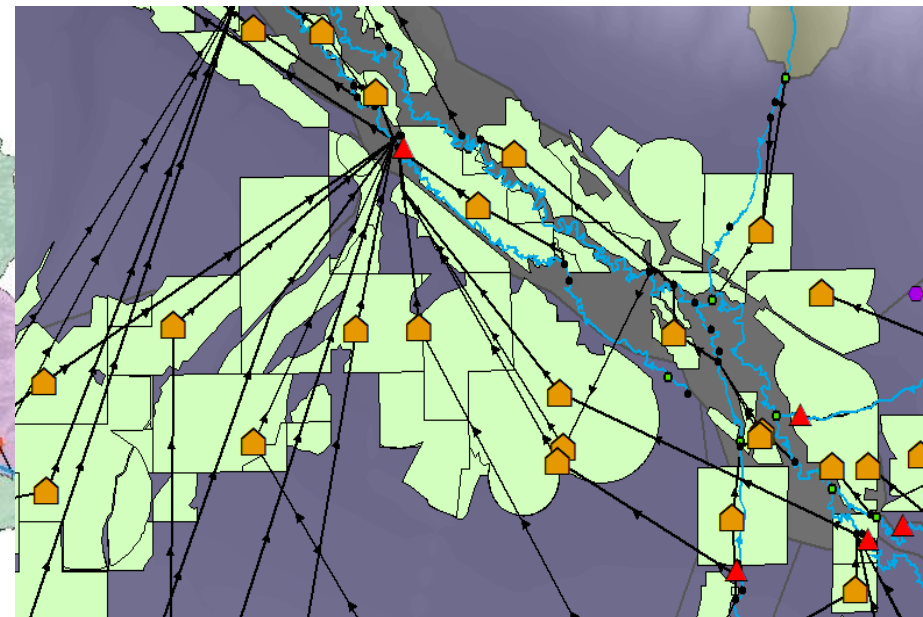
Social

- **Pressure:**
 - None
- **State**
 - Water distribution
 - Personal consumption
 - Employment
- **Impacts**
 - Water borne diseases
 - Access to drinking water
 - Household income

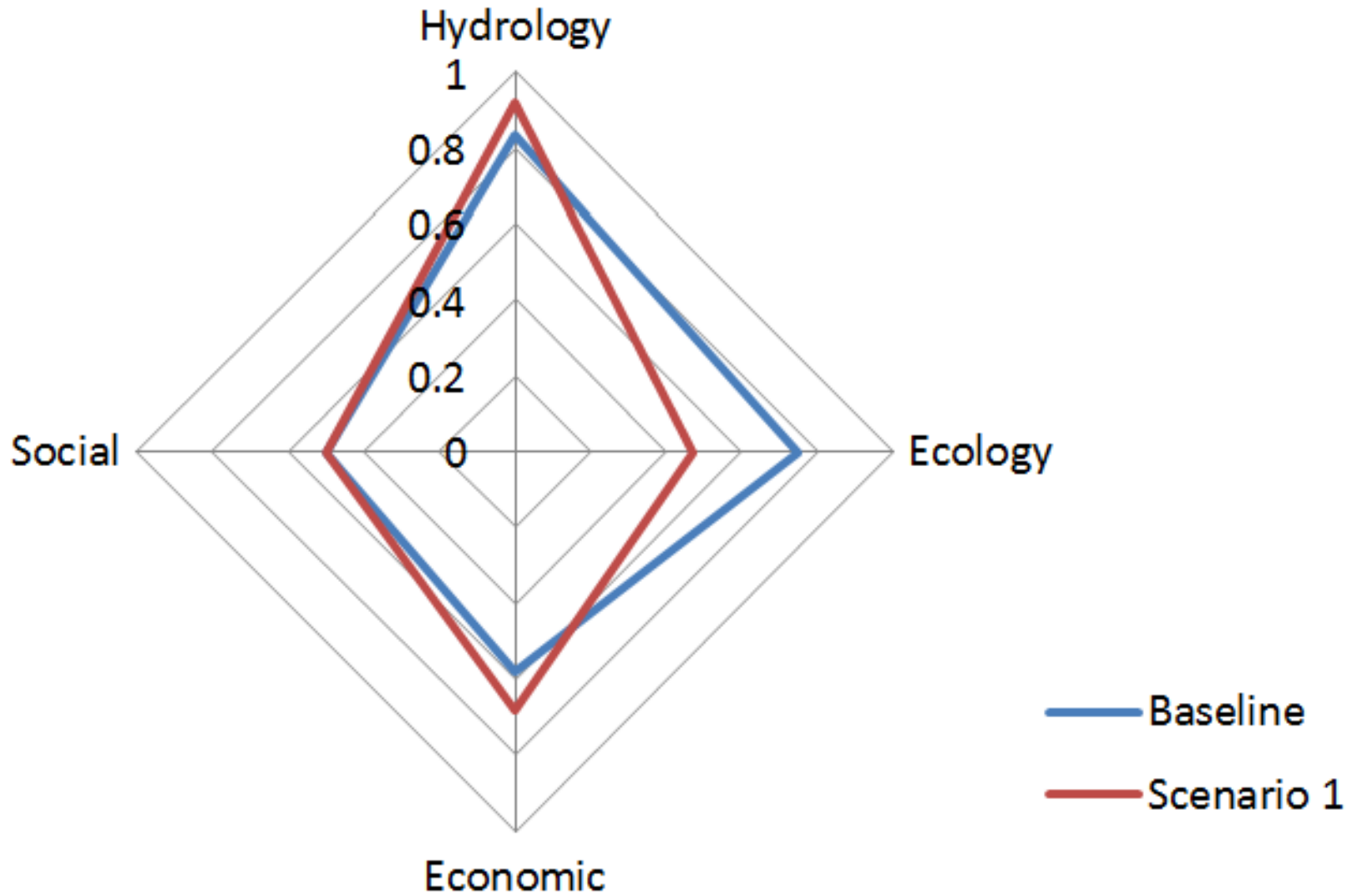


River BASIN Model

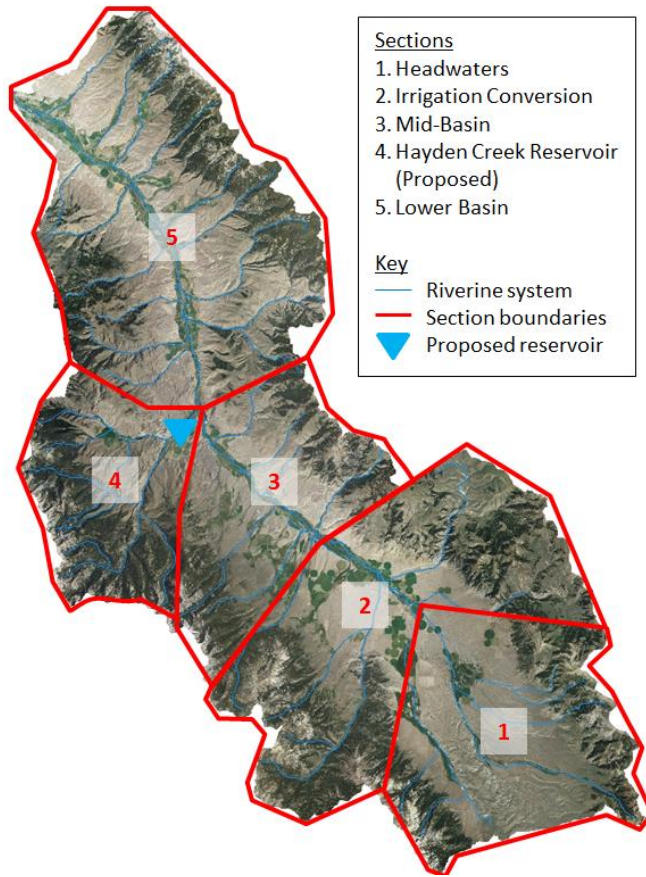
- 65 Catchments
 - NAM inflows
- 322 Water users
- Daily time step
- Calibrated WY 2008 - 2012
- Simulation period:
 - Oct 1, 1999-Sep 30, 2012
- **Indicators: Reliability of water delivery, quantum of water delivered per zone**



Lemhi: Results

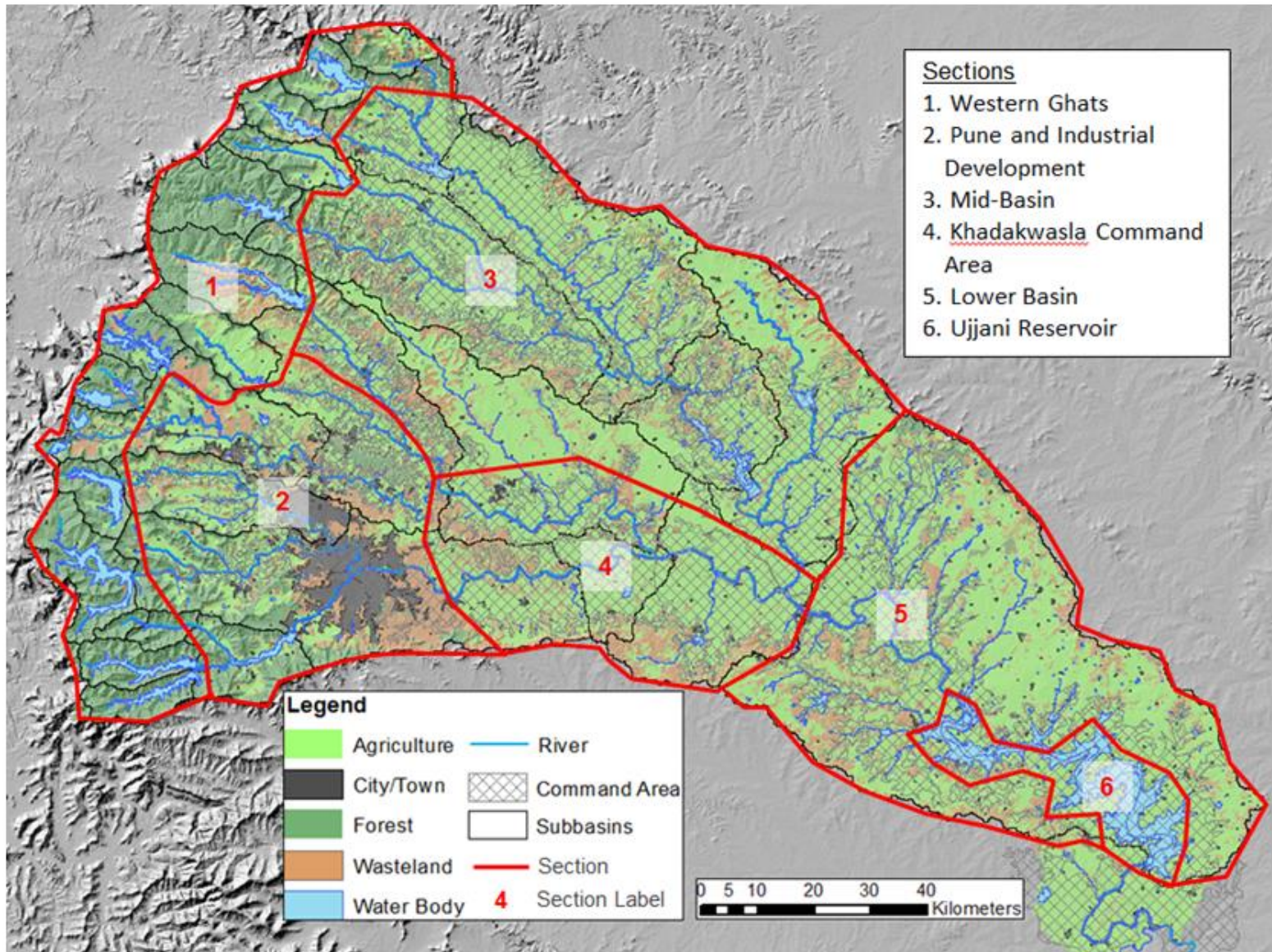


LRB Summary



- **Areas:** Active 2, 4, Altered 3, 5
- **Ecosystems:** river, floodplain, wetland - creation lake
- **EGS provided:** freshwater consumption, food, water regulation, recreation, habitat
- **HWB:** Ability to make a living, recreation
- **Indicators:** Pressures, State, Impact
- **Analysis:** Comparison between alternatives by the SC

RBAF-CT: Upper Bhima Basin



RBAF- Conclusions

- ✓ Formal framework for developing conceptual models of river basins
- ✓ Framework for integrating discipline specific models
- ✓ Evaluating alternative futures across different river basin

carterbwater@gmail.com

