

# Identification of climate resilient alternative field and forage crops for the Southern Great Plains

# Investigators and institutional affiliations

## PRINCIPAL INVESTIGATORS

### □ Texas

- Srinivasulu Ale, Texas A&M AgriLife Research, Vernon, TX
- Sayantan Samanta, Texas A&M AgriLife Research, Vernon, TX
- Darren Hudson, Texas Tech University, Lubbock, TX
- Jourdan Bell, Texas A&M AgriLife Extension, Amarillo, TX

### □ Kansas

- Aleksey Sheshukov, Kansas State University, Manhattan, KS
- Jonathan Aguilar, Southwest Research & Extension Center, Kansas State University, Garden City, KS

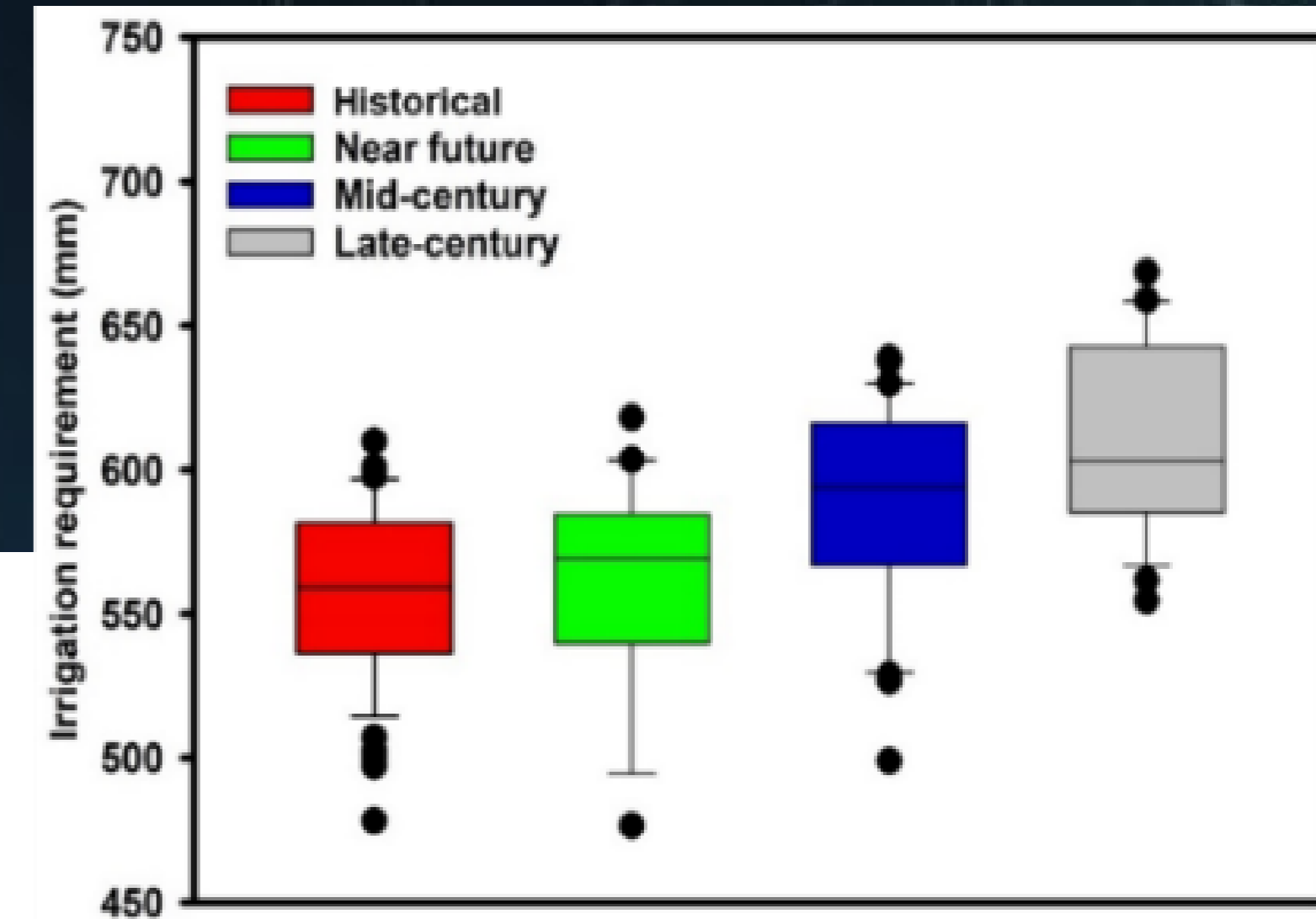
## CO-INVESTIGATORS

### □ Texas

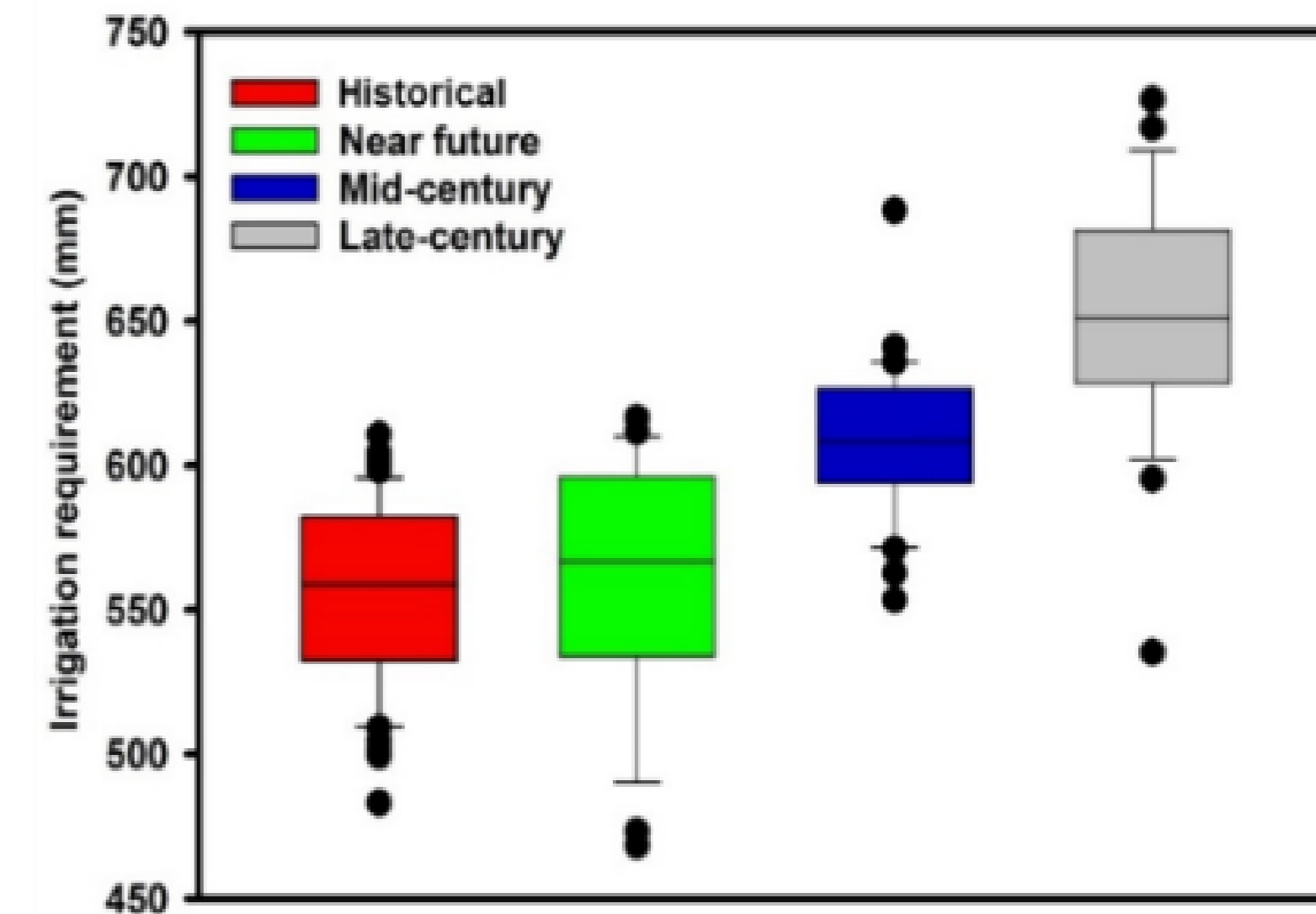
- Robert Lascano, USDA-ARS Cropping Systems Research Laboratory, Lubbock, TX
- Dennis Gitz, USDA-ARS Cropping Systems Research Laboratory, Lubbock, TX
- Tim Goebel, USDA-ARS Cropping Systems Research Laboratory, Lubbock, TX
- Louis Baumhardt, USDA-ARS Conservation and Production Research Laboratory, Bushland, TX

# Rationale ...

- ❑ With the declining water levels in the Ogallala Aquifer, reduced well capacities, and restrictions on groundwater pumping for irrigation, producers may have to partially or fully transition into rainfed crop production.
- ❑ Studies showed that projected warmer and drier future, climate and shifts in precipitation patterns could **increase crop irrigation requirement**.
- ❑ Projected increase in future temperature may create favorable conditions for growing some **alternative crops**.



SSP2-4.5

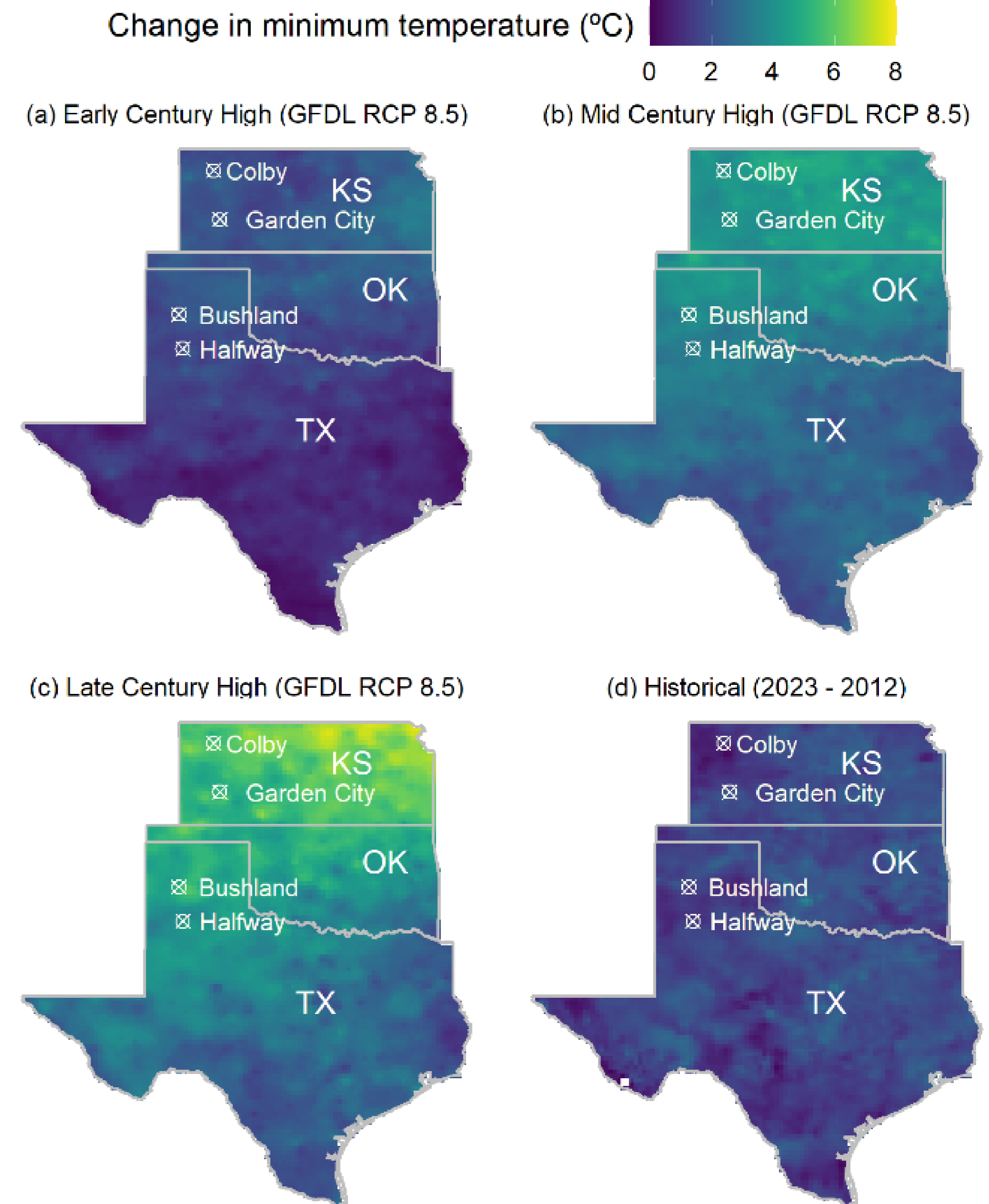


SSP5-8.5

Climate change impact on cotton irrigation requirement in historical and future periods under SSP 2-4.5 and SSP 5-8.5 scenarios at Halfway, TX (Singh et al., 2024).

# Rationale

- ❑ Projections indicated that some portion of the SGP may be exposed to a  $T_{\min}$  increase by  $3.5^{\circ}\text{C}$ ,  $5.2^{\circ}\text{C}$ , and  $7.7^{\circ}\text{C}$  in the early-century (2010–2039), mid-century (2040–2069), and late-century (2070–2099), respectively (Mathews et al., 2018).
- ❑ Some areas in the SGP have already seen  $T_{\min}$  increase up to  $3.7^{\circ}\text{C}$  (~ half a zone of the USDA-reported Plant Hardiness Zones) in 2023 compared to 2012.
- ❑ With such major changes in climate and hardiness zones, the yield potential of historically well-performing crops may be put at risk under water-limited conditions.



Projected changes in  $T_{\min}$  by 30-year period (a, b, and c) under RCP 8.5 scenario with reference to historical period, and (d) actual change in  $T_{\min}$  between 2012 and 2023.  
\*Recreated from Mathews et al. (2018) and the USDA Plant Hardiness Zone Maps.

# Objectives

**Overall Goal:** *Identify suitable alternative field and forage crops for the projected future climate for the SGP region and to assess their feasibility*

Alternative crop suitability index for identifying potential crops

Simulate the performance of identified alternative crops

Assess the economic profitability potential

Educational opportunities to increase awareness among producers

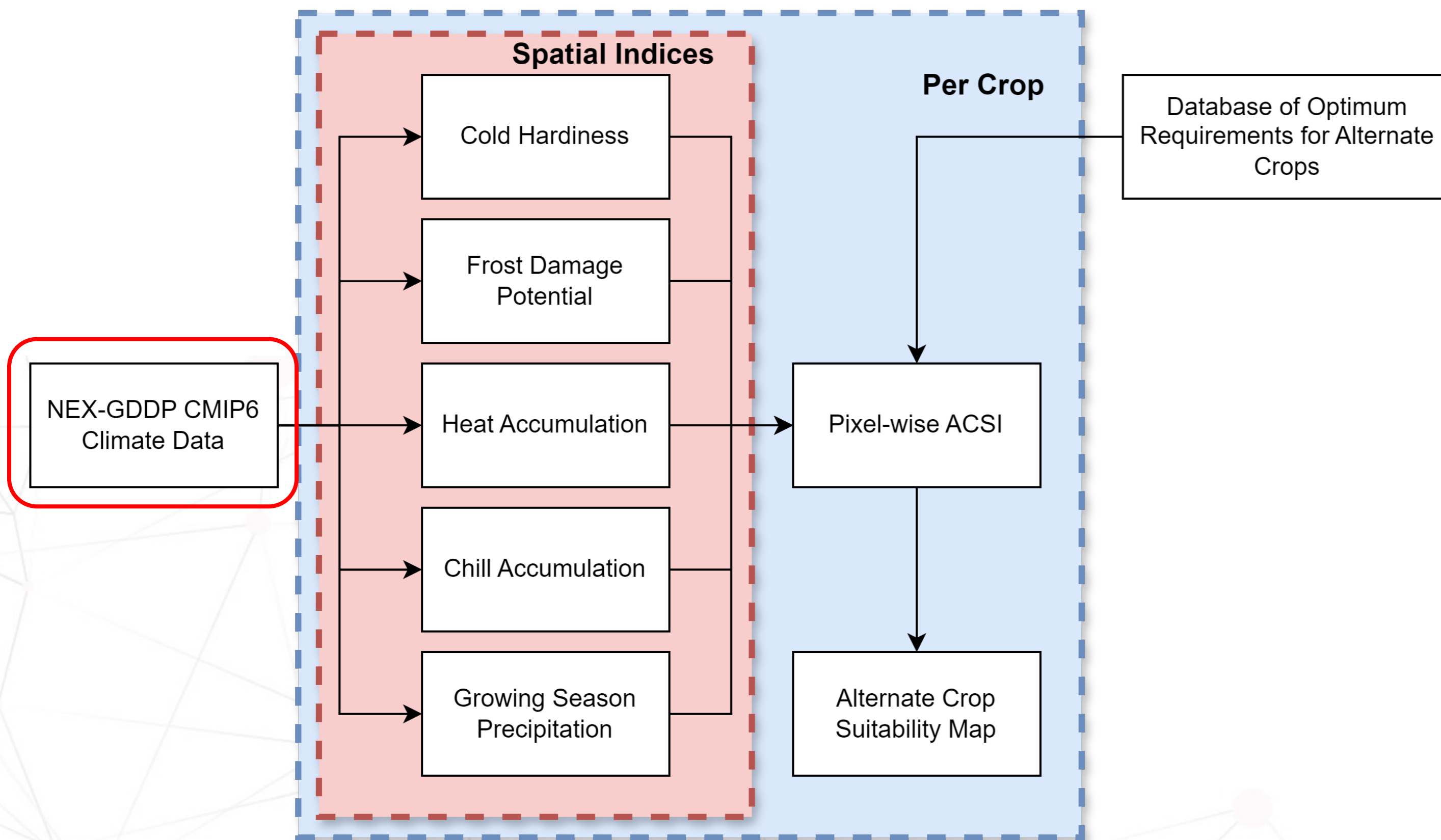
# Objective 1: Alternative crop suitability index (ACSI) for identifying potential crops



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## Methodology:

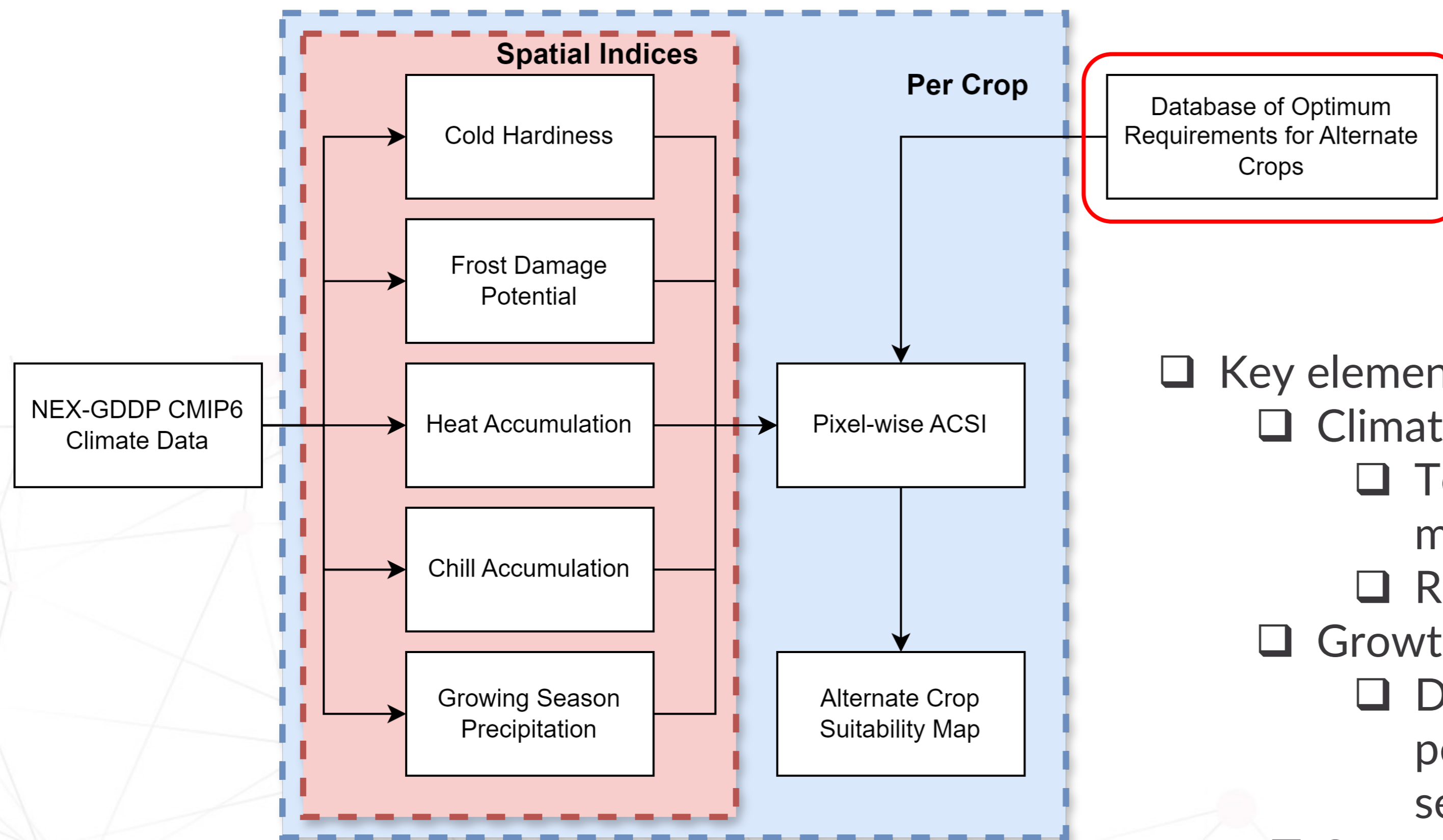


## Climate Data Source:

- ❑ NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP) CMIP6 [1950 – 2099]
- ❑ High resolution (25 km x 25 km) Spatially downscaled and bias-corrected CMIP6 Data
- ❑ Available Variables:  $T_{\min}$ ,  $T_{\max}$ , Precipitation, Solar Radiation, Wind Speed, Relative Humidity

# Objective 1: Alternative crop suitability index (ACSI) for identifying potential crops

## Methodology:



## Crop Requirement Database:

- ❑ The FAO Crop Ecological Requirements Database (ECOCROP)
- ❑ Includes data on air temperature, rainfall, soil type, and photoperiod requirements for over 2,500 crops

## ❑ Key elements:

### ❑ Climatic Requirements:

- ❑ Temperature: Killing, optimum, minimum, and maximum temperature thresholds.
- ❑ Rainfall: Annual precipitation range for crop growth.

### ❑ Growth Cycle:

- ❑ Duration from sowing to harvest (e.g., annual, perennial). Critical stages and environmental sensitivities.

### ❑ Crop category:

- ❑ Pulses, grains, forage, material, vegetables, ...

# Objective 1: Alternative crop suitability index (ACSI) for identifying potential crops

## Pixel-based Suitability Assessment Criteria

- Time Periods:

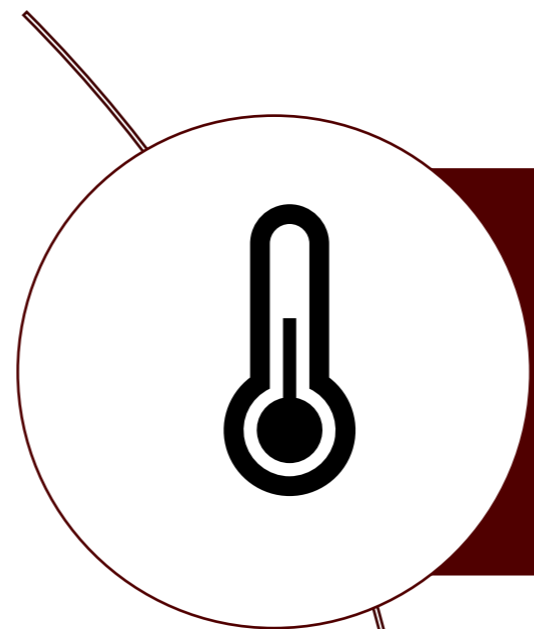
- Historical (1990-2014)
- Near Future (2015–2040)
- Mid-Century (2041–2060)
- Late Century (2081–2100)

- Shared Socioeconomic Pathways:

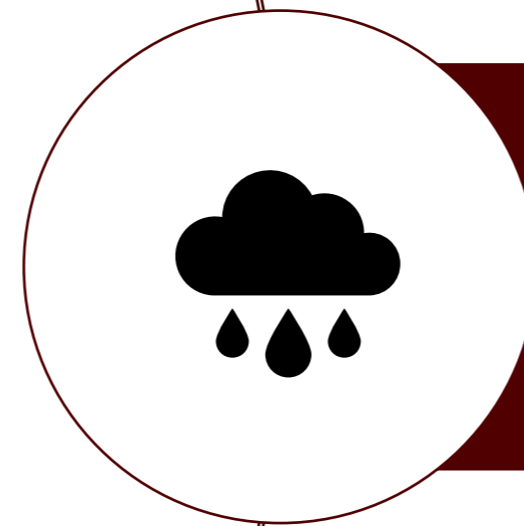
- SSP 2-4.5: Intermediate scenario with moderate climate action.
- SSP 5-8.5: High emissions scenario with minimal climate action.

- Adjustment of start and end of growing season.

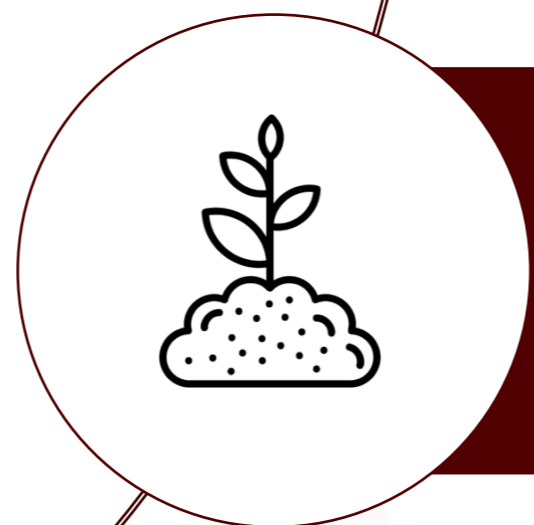
- Season starts when temperature exceeds Killing Temperature
- Season ends: Season start + mean growing season length



Mean temperature during the growing season must fall within the crop's optimal temperature range.



Total precipitation plus allowable groundwater pumping during the growing season is within the crop's water requirements.

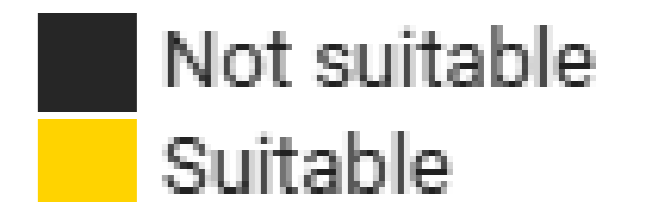


Soil & terrain conditions match with plant requirements

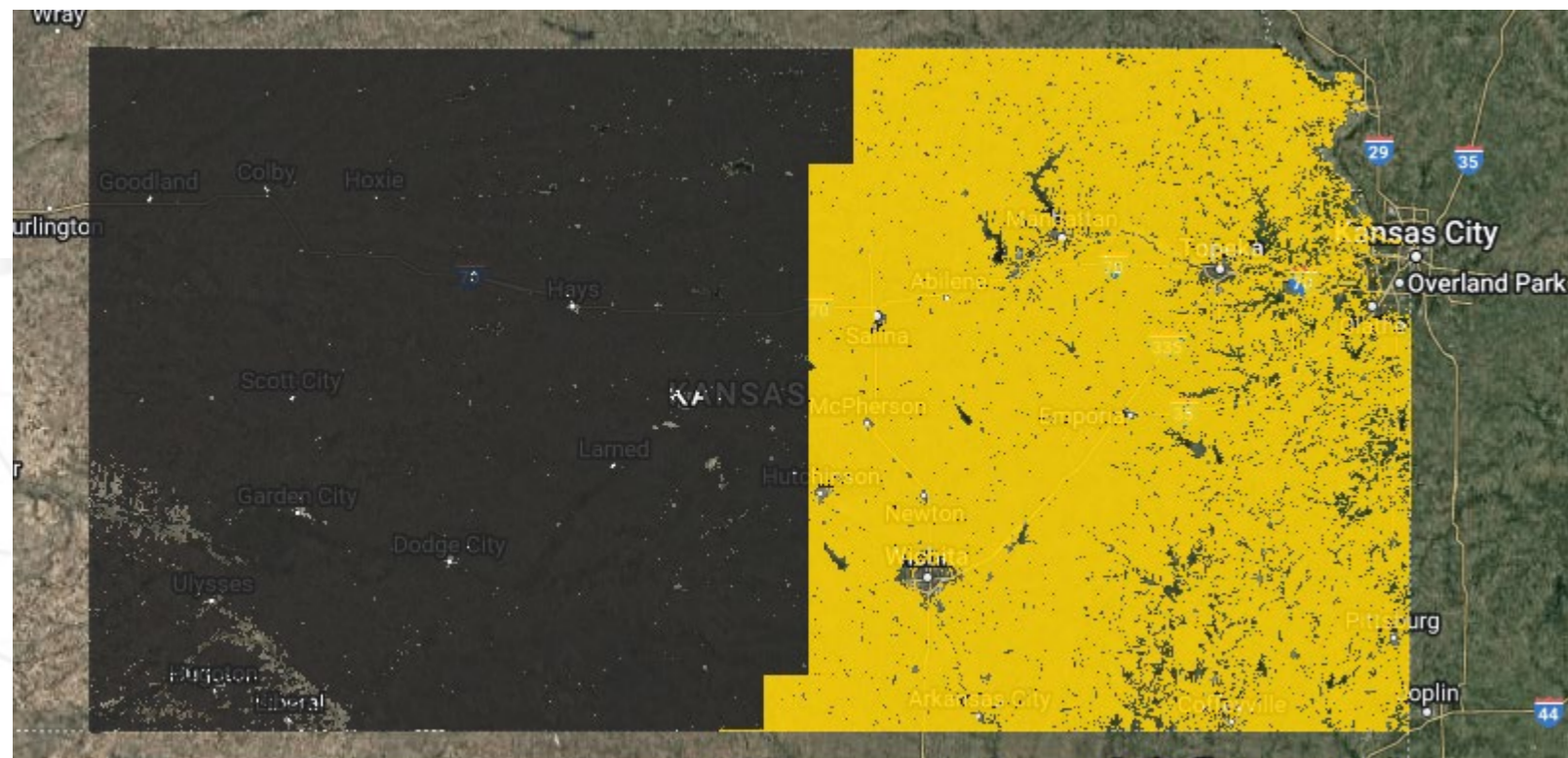


# Objective 1: Alternative crop suitability index (ACSI) for identifying potential crops

## Pixel-based Precipitation Suitability for Dryland Cotton

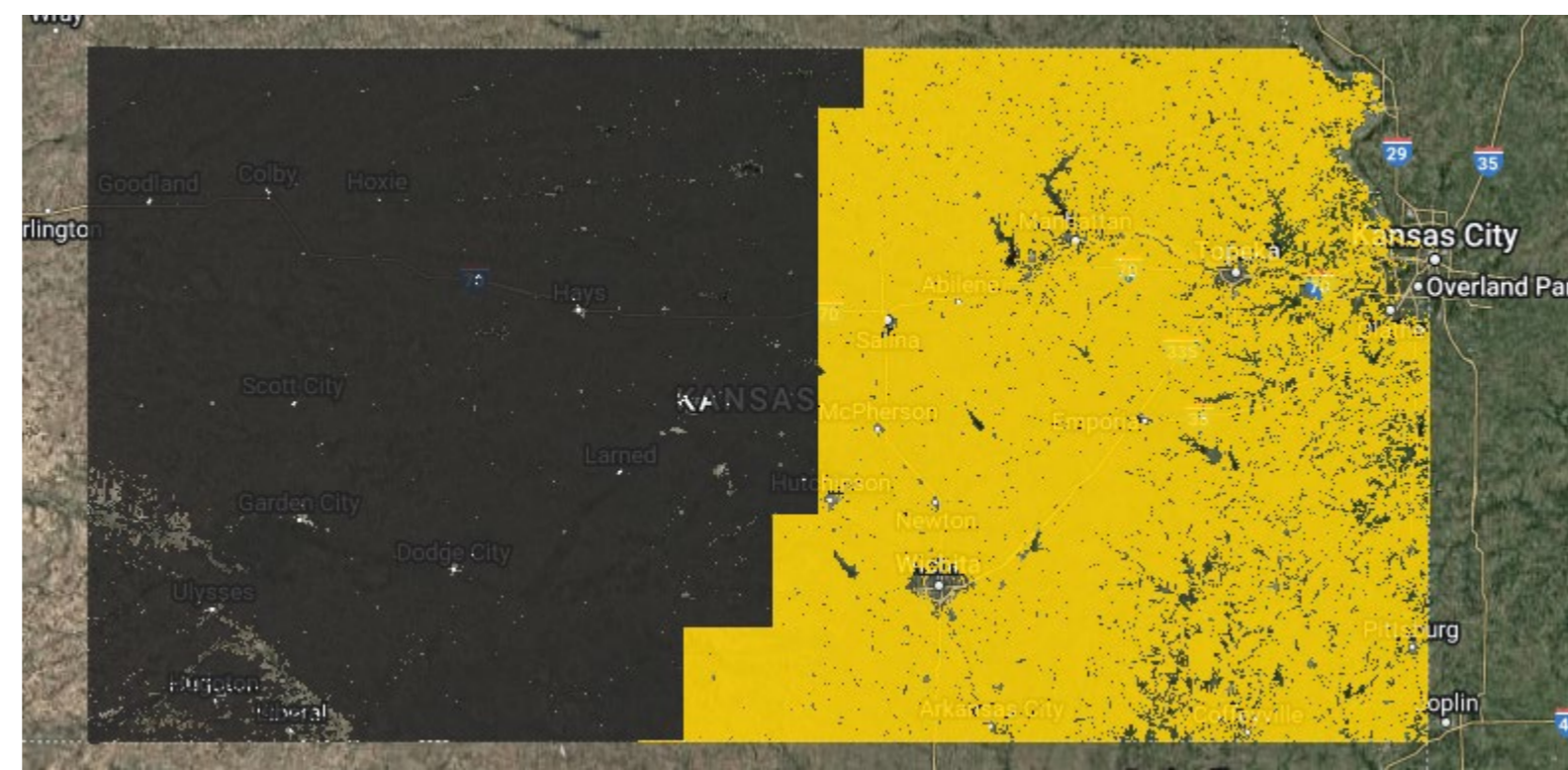


KS (Historical)



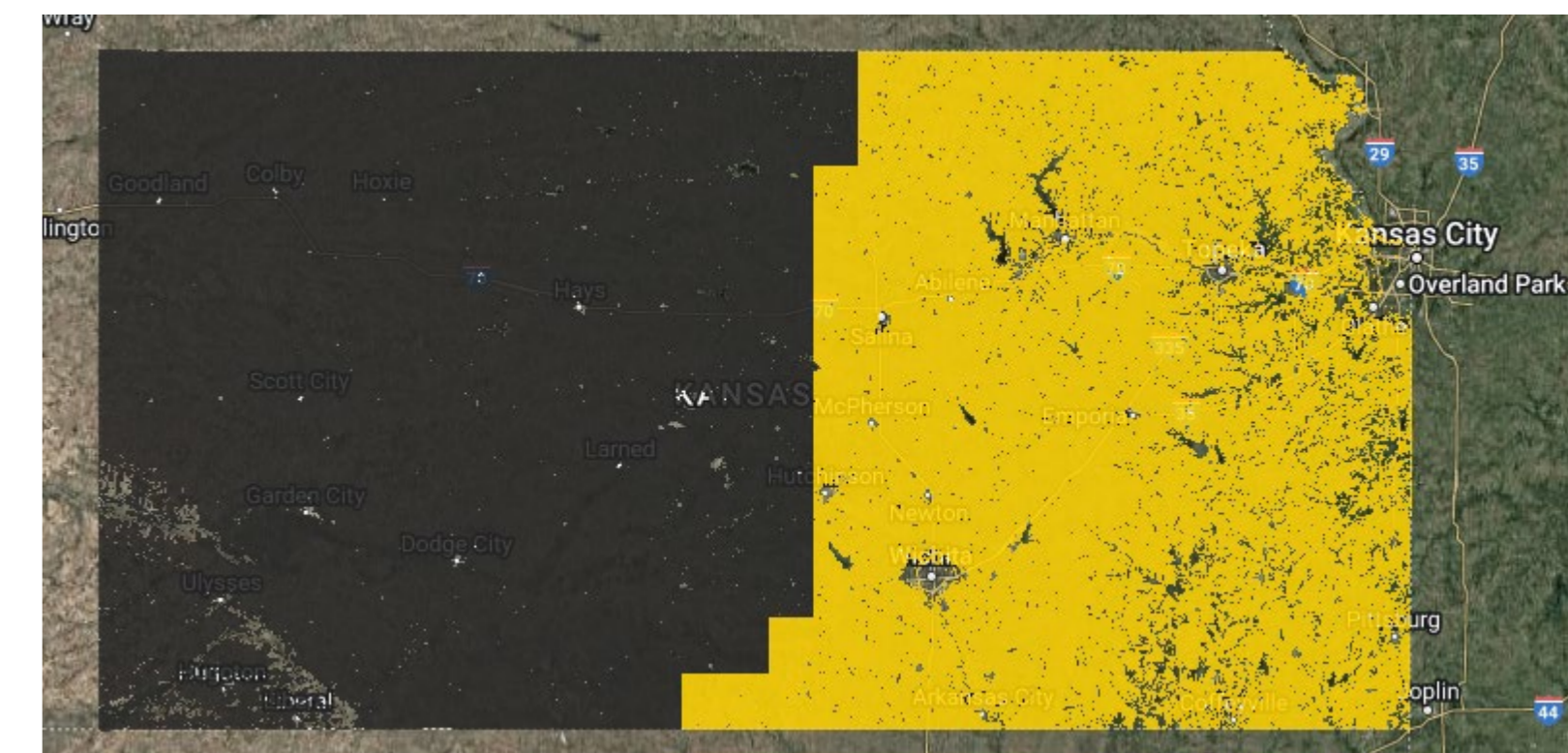
Suitability Area: 42.5%

KS (Near Future; SSP 2-4.5)



Suitability Area: 45.0%

KS (Mid Century ; SSP 2-4.5)



Suitability Area: 43.4%

# Objective 2: Simulate the performance of identified alternative crops (EPIC-Environmental Policy Integrated Climate Modeling)

## Texas Sites

### Bushland

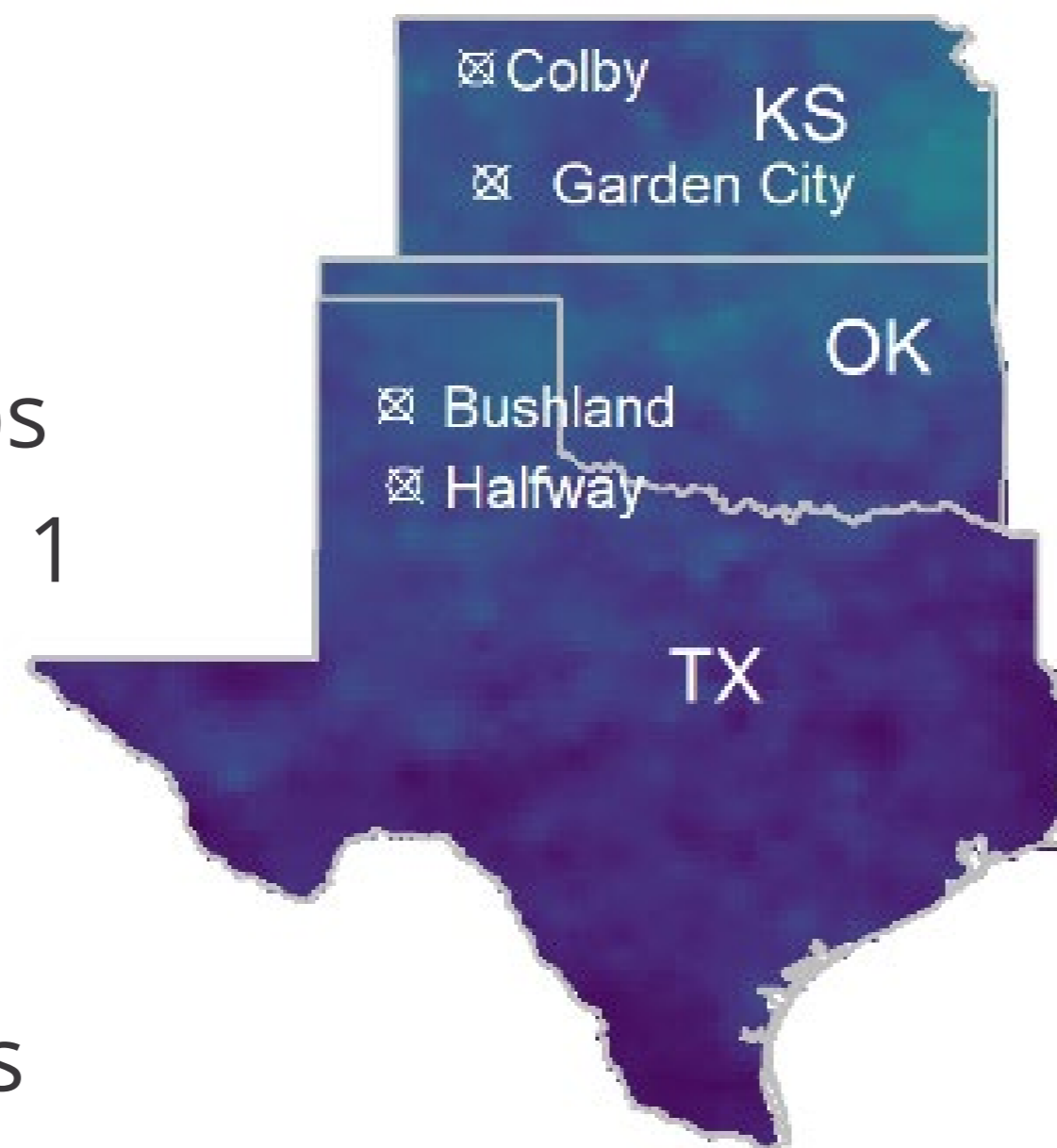
Baseline crop: *Corn*

Alternate crops: Selected crops identified from Objective 1

### Halfway

Baseline crop: *Cotton*

Alternate crops: Selected crops identified from Objective 1



## Kansas Sites

### Colby

Baseline crop: *Sorghum*

Alternate crop: *Cotton*; Crops identified from Objective 1

### Garden City

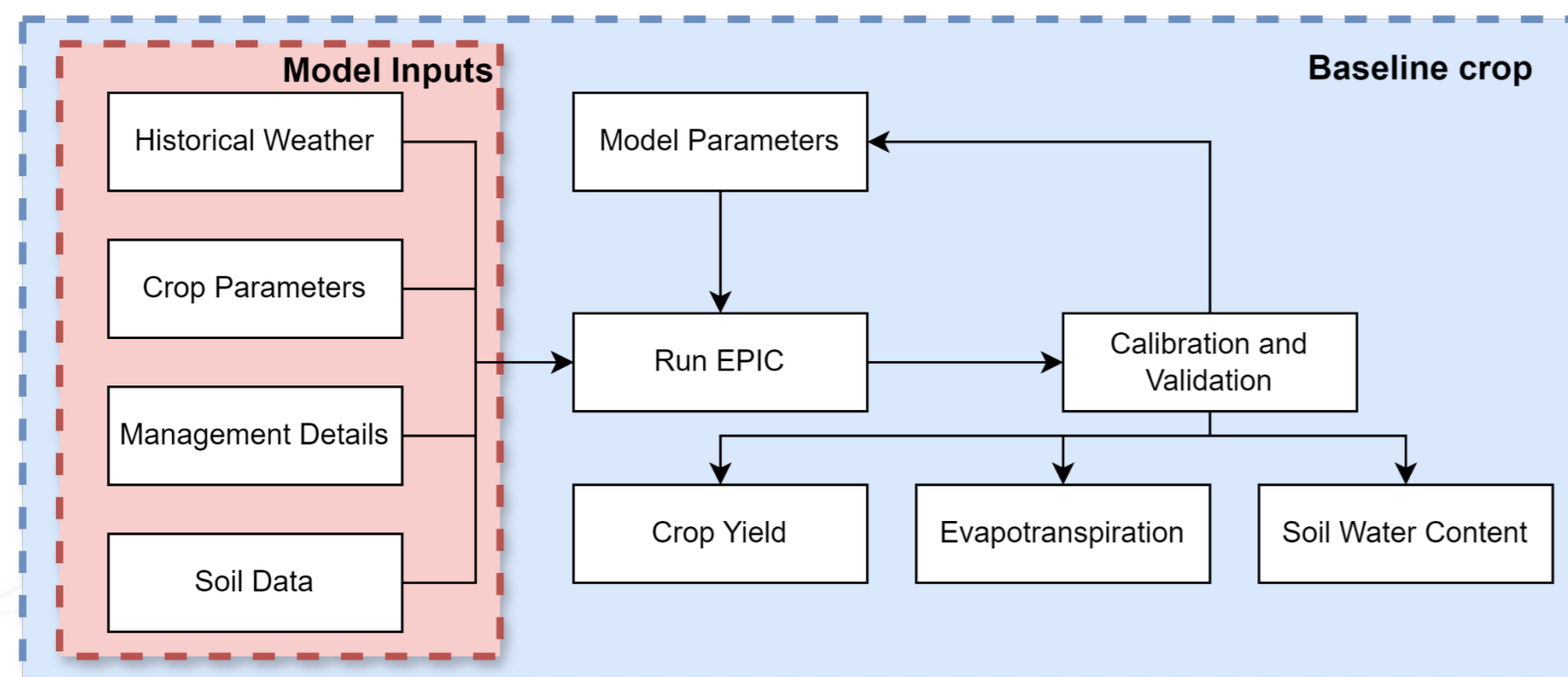
Baseline crop: *Corn*

Alternate crop: *Cotton*; Crops identified from Objective 1

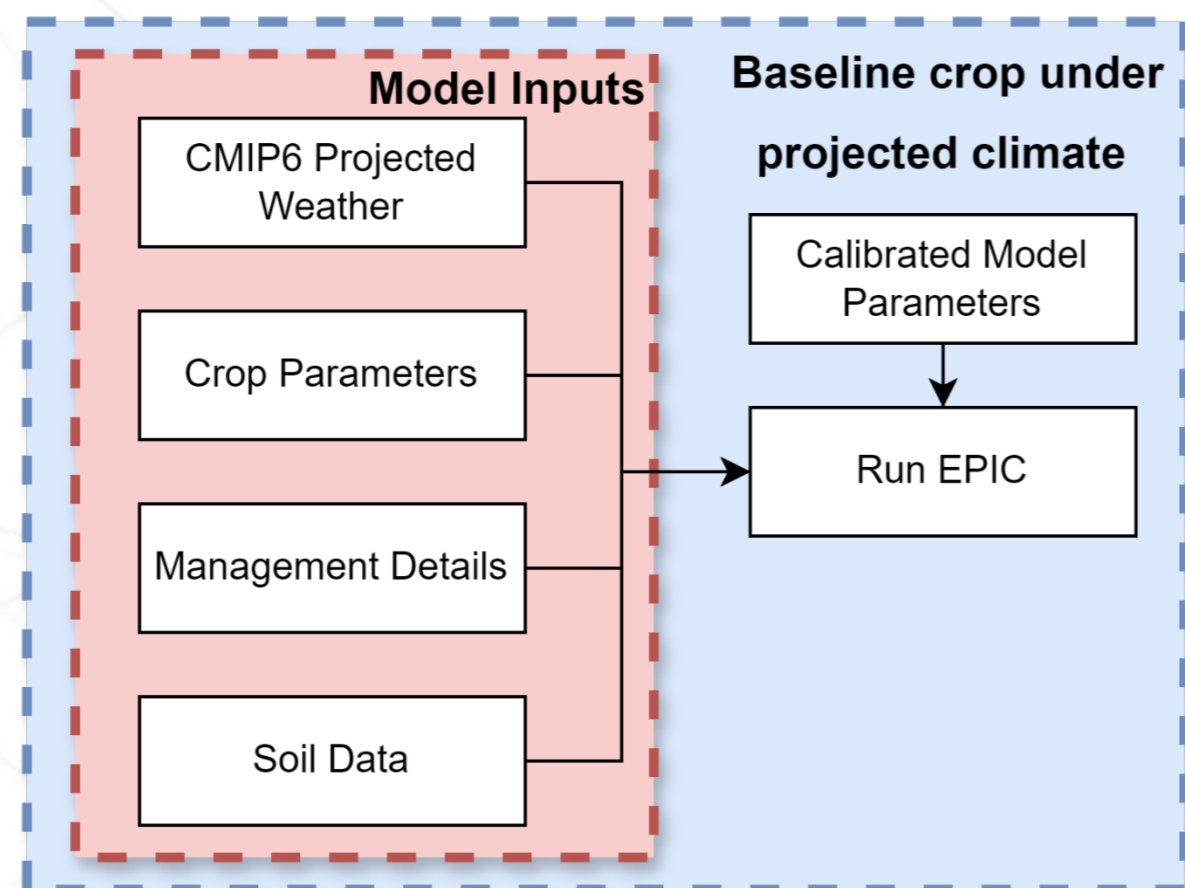
# Objective 2: Simulate the performance of identified alternative crops (EPIC-Environmental Policy Integrated Climate Modeling)

## Methodology:

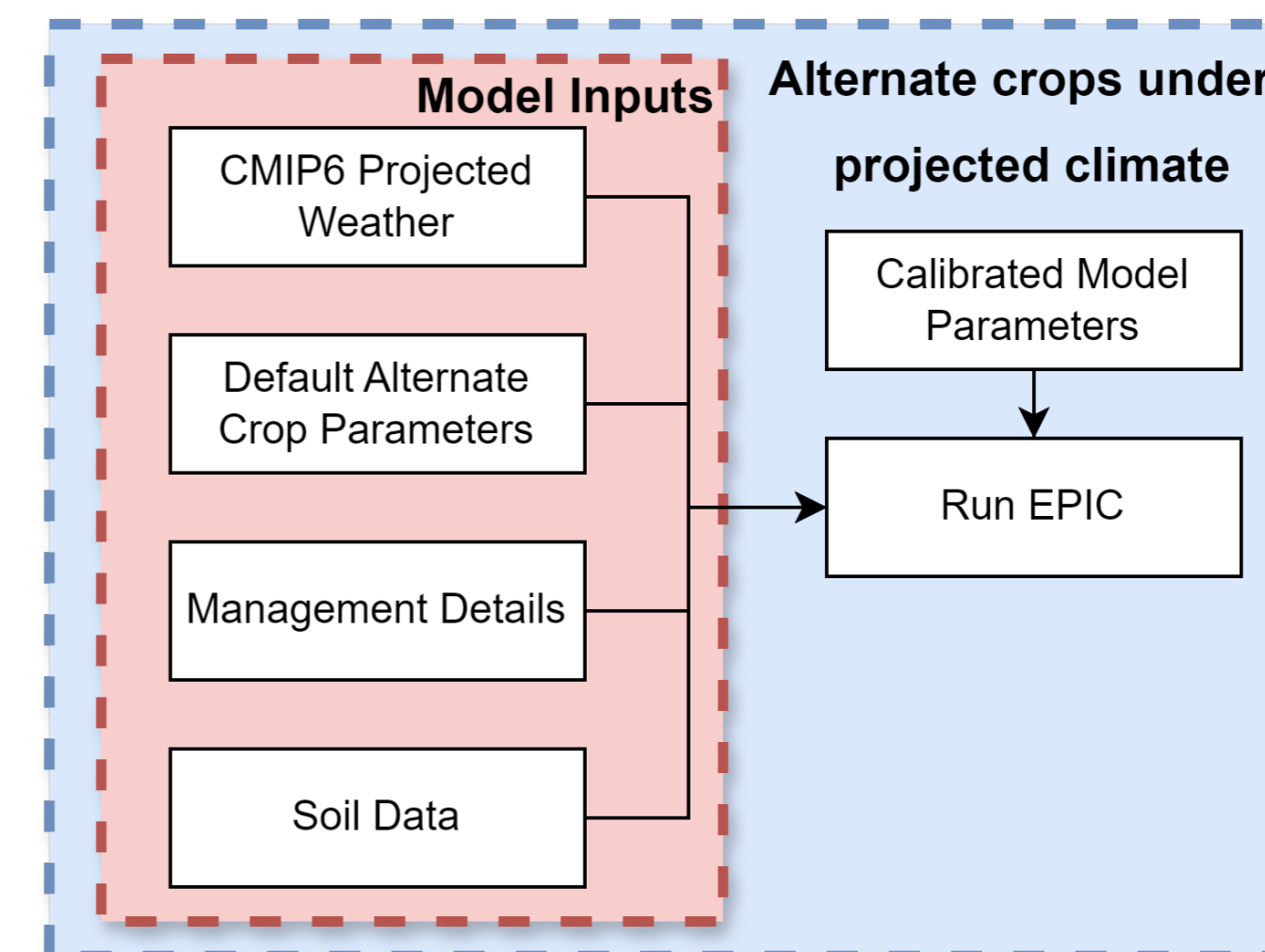
**Step 1:** Baseline model calibration for each site



**Step 2:** Extend calibrated models using future climate projections



**Step 3:** Develop alternate scenarios using calibrated model parameter and default crop parameters for alternate crops



**Step 4:** Compare yield, water use, and crop water productivity between baseline and alternate crops under projected climate.

-Three future periods would be used for comparison:

- Near Future (2015–2040)
- Mid-Century (2041–2060)
- Late Century (2081–2100)

# Objective 3: Assess the economic profitability potential of alternate crops

## Methodology:

### Step 1: Comparison of economic potential of alternate and baseline crops

- Estimate cost of crop production using yield data from baseline EPIC models
- Compare net profitability of alternate crops and baseline crops

### Step 2: Risk analysis using a Monte Carlo simulation of expected yields/revenues for alternative crops

- Risk analysis will be performed using expected yield data from the EPIC models
- Using appropriate yield distributions, the Monte Carlo simulations of crop and revenue distributions will be performed

# Objective 4: Educational opportunities to increase awareness among producers

- ❑ Extension publications with recommendations on alternative crops and economic potential for adaptation.
- ❑ Presentations at stakeholder leadership meetings, field days, and other advisory meetings, as well as at conferences.
- ❑ Results will be adapted for curriculum at the annual North Plains Groundwater Conservation District Master Irrigator program (Texas).
- ❑ The curriculum of BAE 669 (watershed modeling) at KSU will contain special topics on crop & forage production modeling

# Timeline

		2024				2025												2026								
		S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	
Objective 1	Alternate crop optimum requirement database		█	█	★																					
	ASCI development and identification of alternate crops		█	█	★	█	█	█																		
Objective 2	Kansas baseline EPIC model development		█	█		█	█	█	█	█	█	█	█													
	Texas baseline EPIC model development					█	█	█	█	█	█	█	█													
	Kansas alternate EPIC model development													█	█	█	█	█	█	█	█					
	Texas alternate EPIC model development													█	█	█	█	█	█	█	█					
Objective 3	Economic evaluation					█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
Objective 4	Educational opportunities and outreach																	█	█	█	█	█	█	█	█	█

# Acknowledgement

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Thank you for your attention!!  
Contact info:  
[Srini.Ale@ag.tamu.edu](mailto:Srini.Ale@ag.tamu.edu)  
[Sayantan.Samanta@ag.tamu.edu](mailto:Sayantan.Samanta@ag.tamu.edu)