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Terra-Fresh

Technology-Enabled, Rapid-Response Fresh Food Supply Chains (TERRa-Fresh) Complementary Regions

Grace Neal, Madhav Regmi and Omar Ahumada

Arizona State University
FFAR
NM State University
ILPIL International Logistics & Productivity Improvement lab

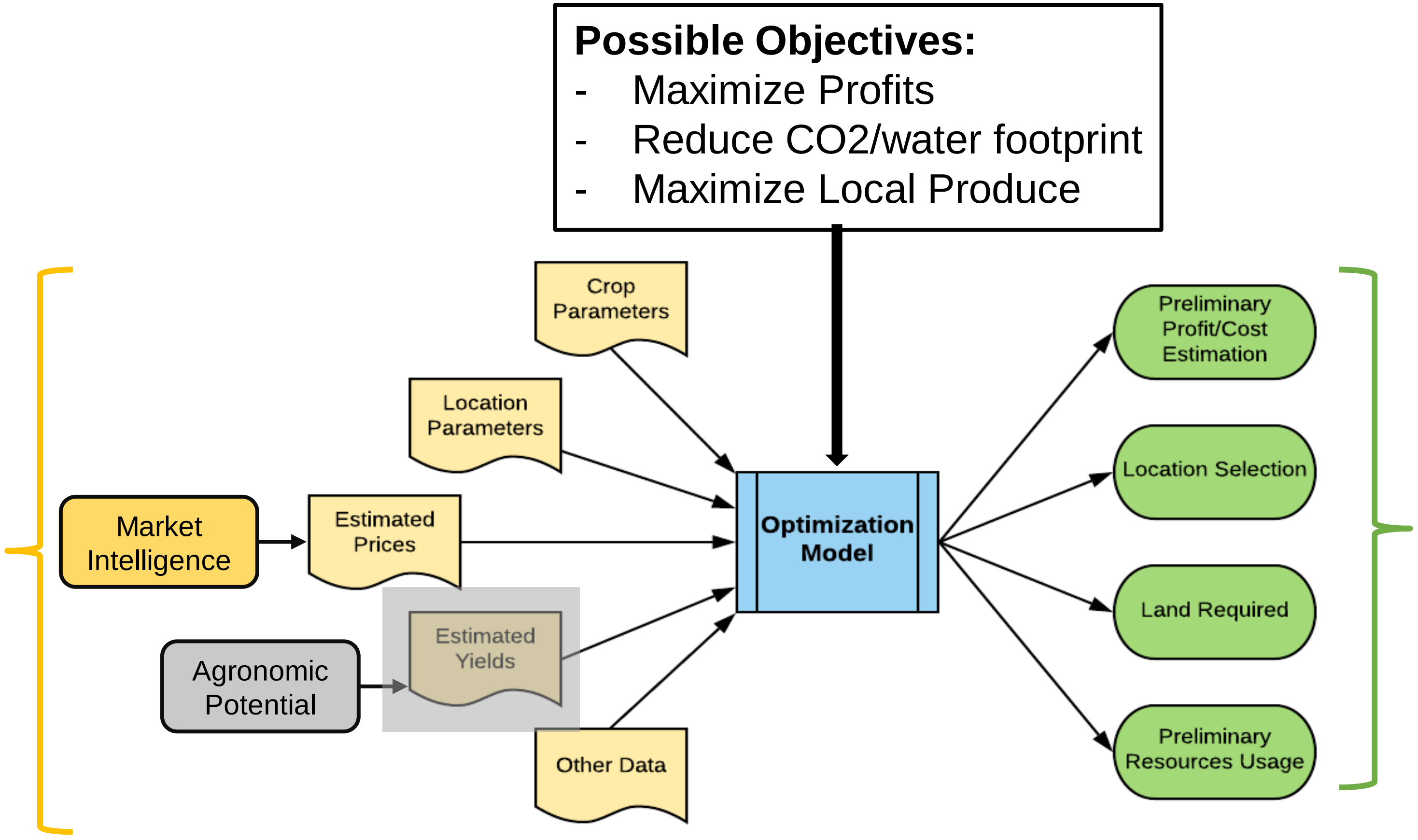
Agenda

- Background
- A SIMPLE Crop Model
- Complementary Regions
- Climate Change
- Conclusions and Future Work

Background

Model Inputs:

Specific parameters that helps modelling the planning process



Model Outputs:

Results that can be used to assist the planning process, depending on the desired objective

Analytics: A SIMPLE Crop Model

- Simple generic crop model (SIMPLE) developed by Zhao et al. (2019) is used to predict crop yield.
- Inputs for SIMPLE model includes crop-specific parameters, daily weather data, and water availability.
- Following Zhao et al. (2019), daily biomass growth rate $(Biomass_{rate})$ is estimated as:

$$Biomass_{rate} = Radition \times fSolar \times RUE \times f(CO_2) \times f(Temp) \times \min(f(Heat), f(Water))$$

- $fSolar$ is the fraction of solar radiation ($Radition$) intercepted by a crop canopy.
- RUE is the radiation use efficiency. [=1]
- $f(CO_2)$ measures the CO2 impact on biomass growth. [=1]
- $f(Temp)$ measures the temperature impact on biomass growth.
- $f(Heat)$ measures the heat stress on biomass growth.
- $f(Water)$ measures the heat stress on biomass growth. [=1]

SIMPLE Model Parameters and Inputs

$$Biomass_{rate} = Radition \times fSolar \times RUE \times f(CO_2) \times f(Temp) \times \min(f(Heat), f(Water))$$

$$Solar = \begin{cases} \frac{fSolar\_max}{1+e^{-0.01\times(TT-I50A)}}, & leaf\ growth\ period \\ \frac{fSolar\_max}{1+e^{0.01\times(TT-(T_{sum}-I50B))}}, & leaf\ senescence\ period \end{cases}$$

$$f(\text{Temp}) = \begin{cases} 0 & T < T_{base} \\ \frac{T-T_{base}}{T_{opt}-T_{base}} & T_{base} \le T < T_{opt} \\ 1 & T \ge T_{opt} \end{cases}$$

$$f(\text{heat}) = \begin{cases} 1 & T_{max} \le T_{heat} \\ 1 - \frac{T_{max}-T_{heat}}{T_{extreme}-T_{heat}} & T_{heat} < T_{max} \le T_{extreme} \\ 0 & T_{max} > T_{extreme} \end{cases}$$

- I_{50A} *is the cumulative temperature required to intercept 50% of solar radiation during canopy closure [=520].*
- I_{50A} *is the cumulative temperature required to 50% of radiation interception during canopy senescence [=400].*

Crop Name	Harvest Index	T_base	T_opt	T_heat	T_extreme	Dry Matter
Tomato	0.68	6	26	32	45	6%
Lettuce	0.68	6	26	32	45	10%
Celery	0.68	11	31	37	50	6%
Bell Pepper	0.68	11	31	37	50	8%
Carrot	0.7	6	26	32	45	12%
Cucumber	0.68	11	31	37	50	4%
Onion	0.85	6	26	32	45	10%
Green Bean	0.4	11	31	37	50	10%
Cauliflower	0.68	6	26	32	45	8%

- T_{base} *and* T_{opt} *are the base and optimal temperature for biomass growth.*
- T_{max} , T_{heat} *and* $T_{extreme}$ *respectively represents daily maximum temperature, temperature threshold when biomass growth rate starts to reduced by heat stress, and temperature threshold when biomass growth rate rate reaches 0 due to heat stress.*

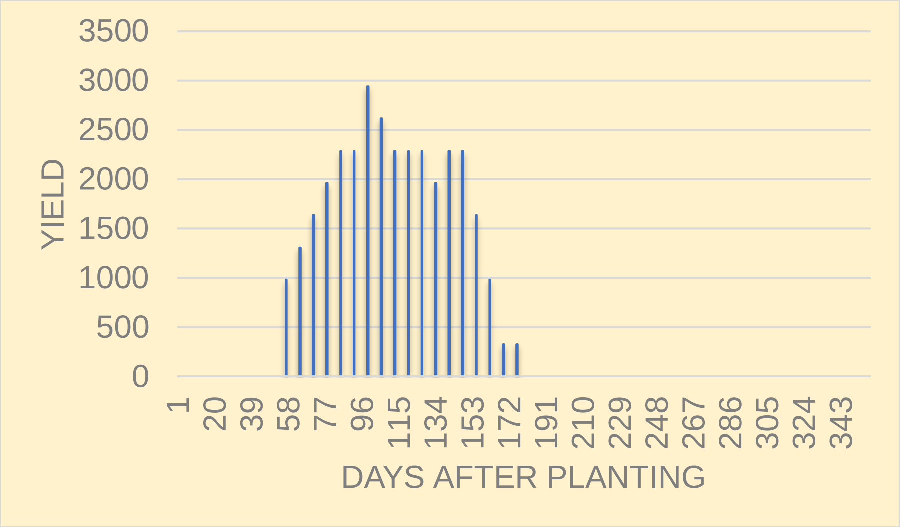
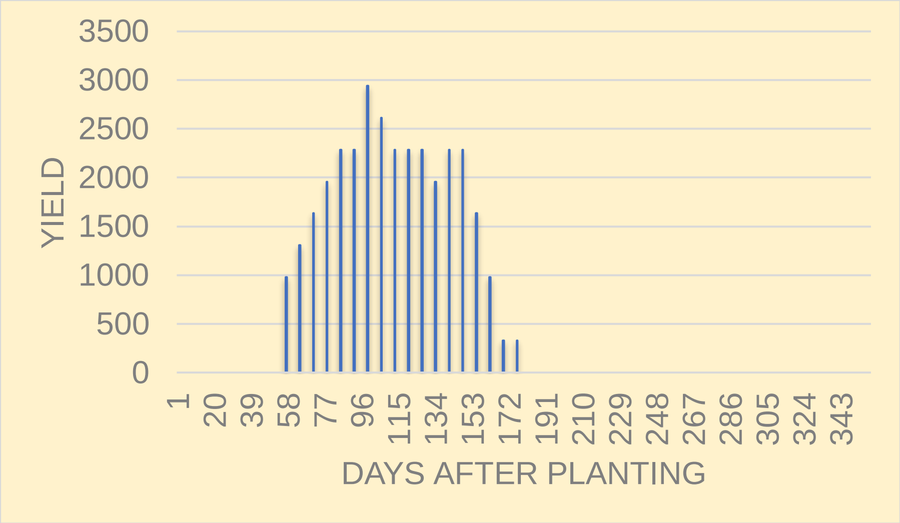
Estimating Yield using SIMPLE Crop Model

- The cumulative biomass until i^{th} day becomes:

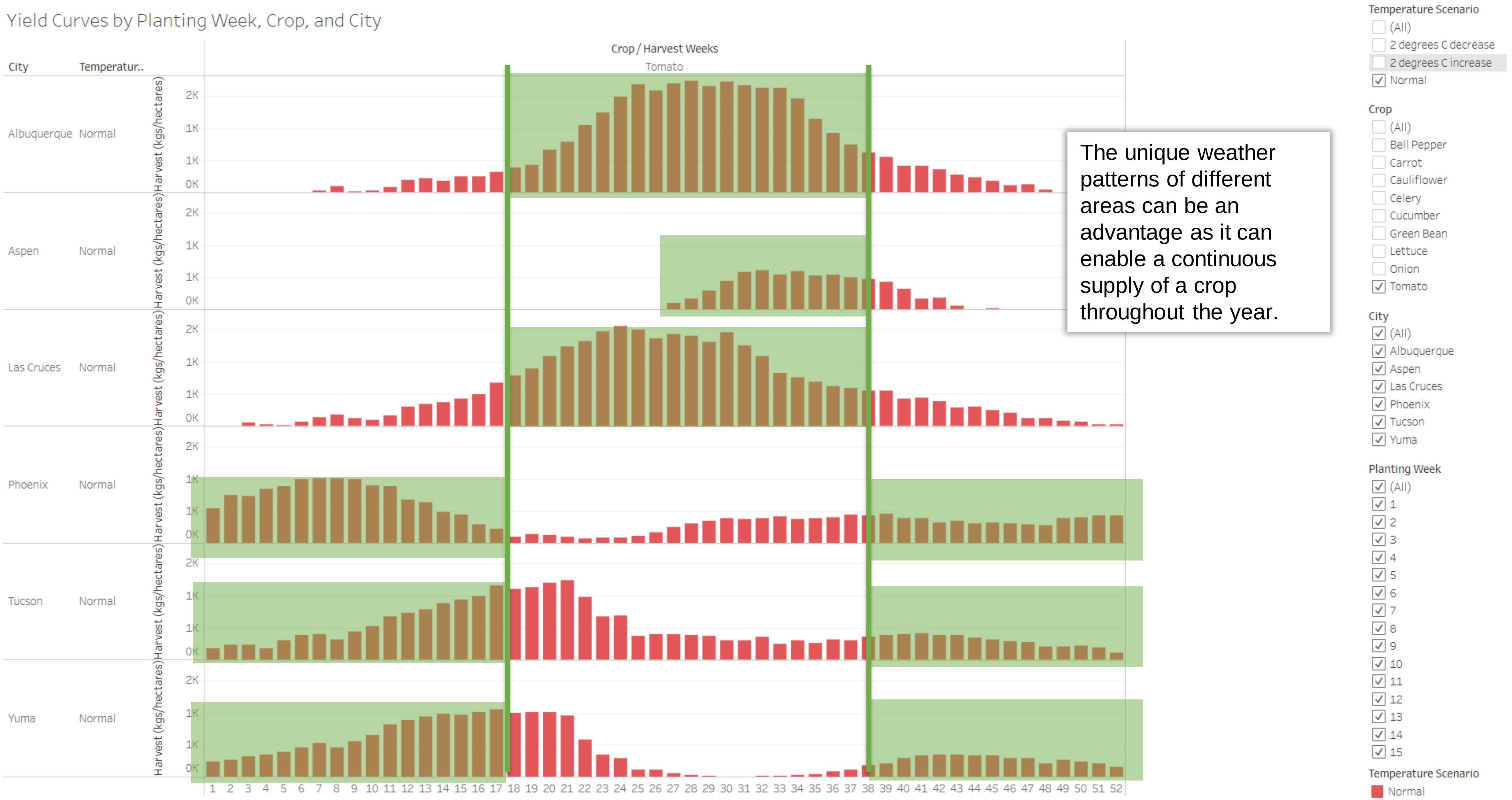
$$Biomass\_cum_{i+1} = Biomass\_cum_i + Biomass\_rate$$

- Finally, the total crop yield can be predicted as:

$$Yield = Biomass\_cum_{maturity} \times Harvest\ Index$$

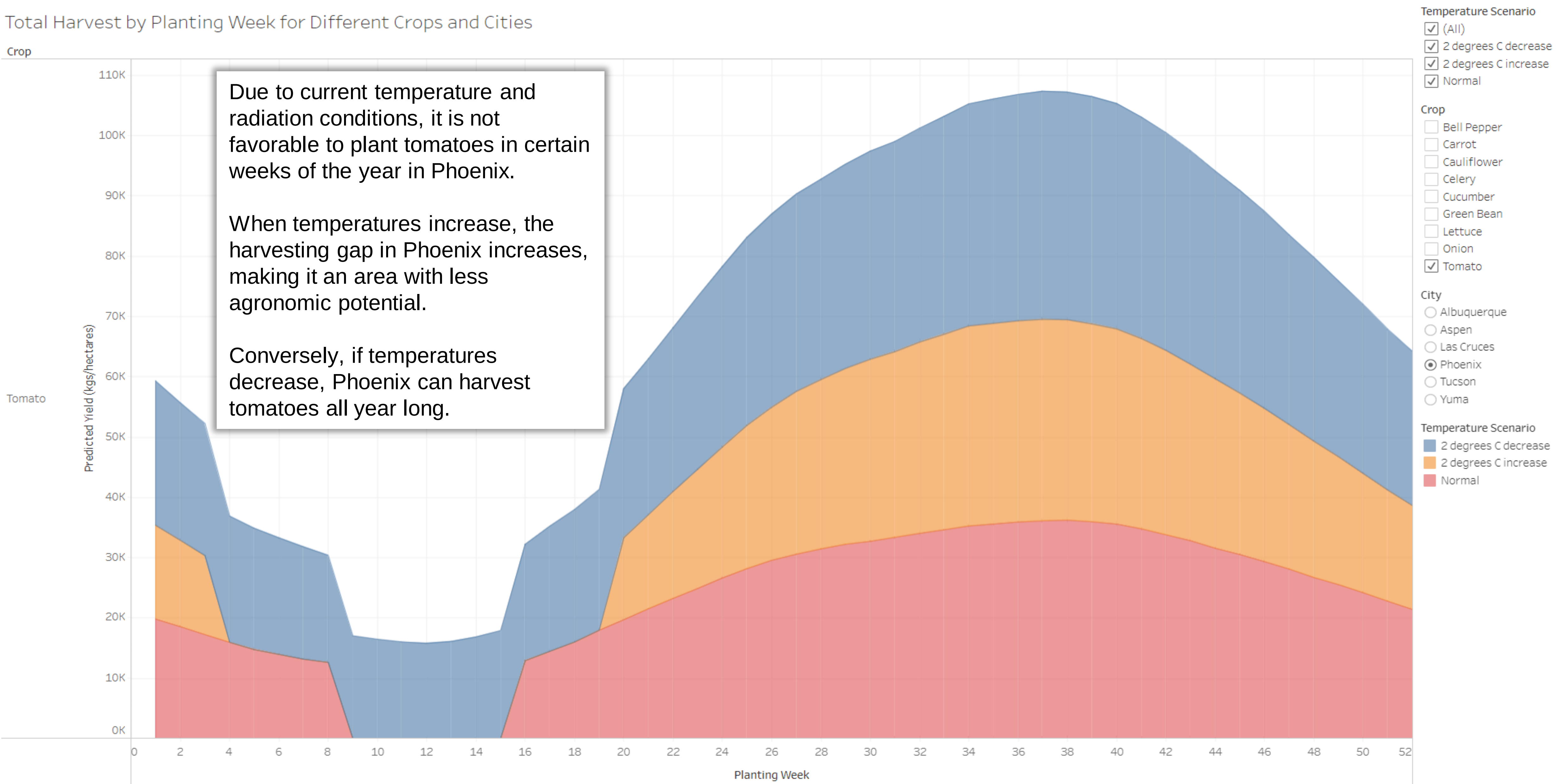
Predicted Yields for Tomato in Las Cruces	
Planting Date : Feb 5 (Total Yield: 34,500)	Planting Date : March 4 (Total Yield: 32,659)
	

Complementary Regions



The unique weather patterns of different areas can be an advantage as it can enable a continuous supply of a crop throughout the year.

Climate Change Effects on Crop Yields

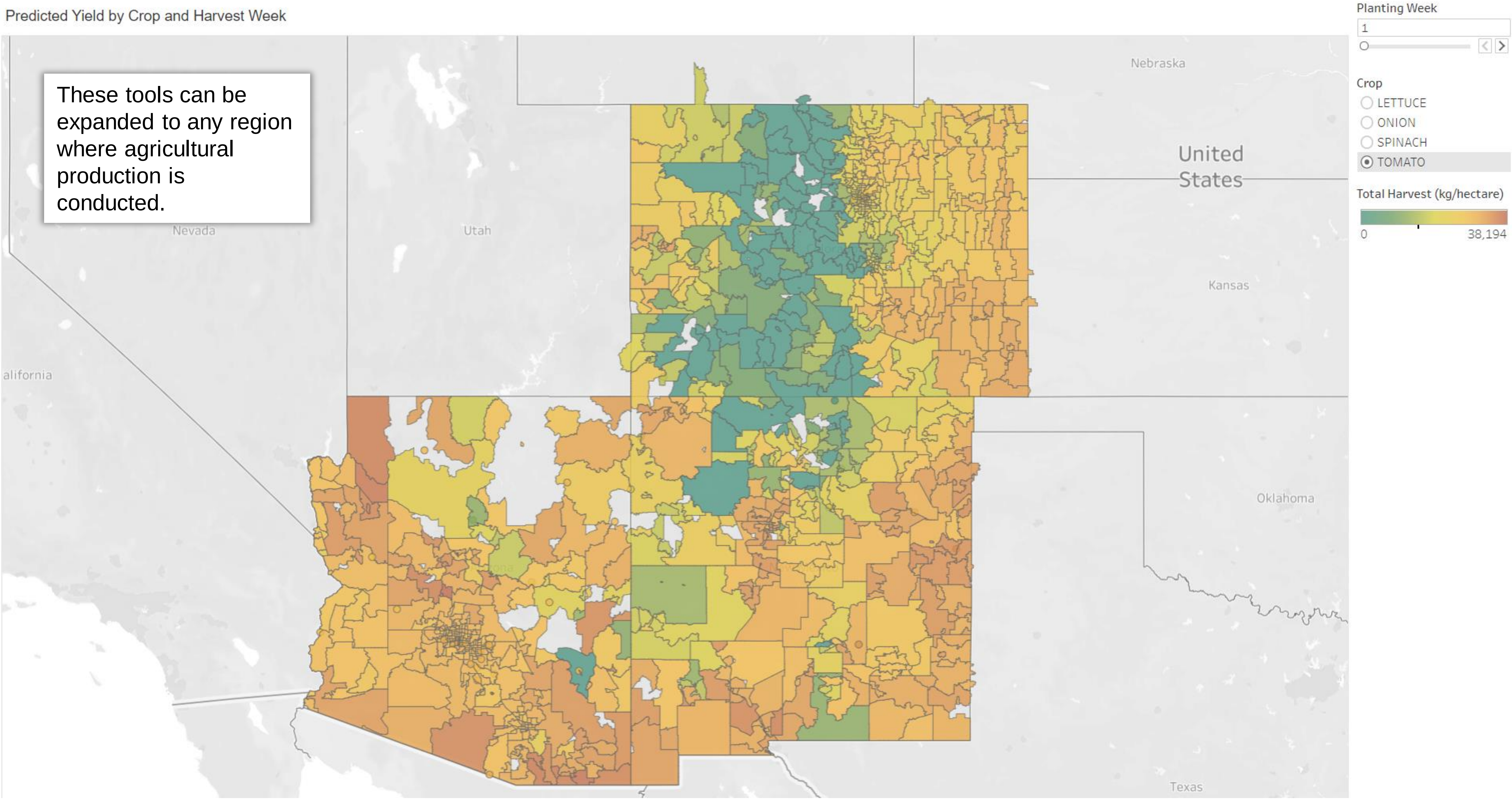


Due to current temperature and radiation conditions, it is not favorable to plant tomatoes in certain weeks of the year in Phoenix.

When temperatures increase, the harvesting gap in Phoenix increases, making it an area with less agronomic potential.

Conversely, if temperatures decrease, Phoenix can harvest tomatoes all year long.

Expansion to 5-Digit Zip Code Regions



These tools can be expanded to any region where agricultural production is conducted.

Terra-Fresh Tools Demo

Yield Estimation Tool

Simulate crop yields through different regions of Arizona, Colorado and New Mexico

Predicted Yield

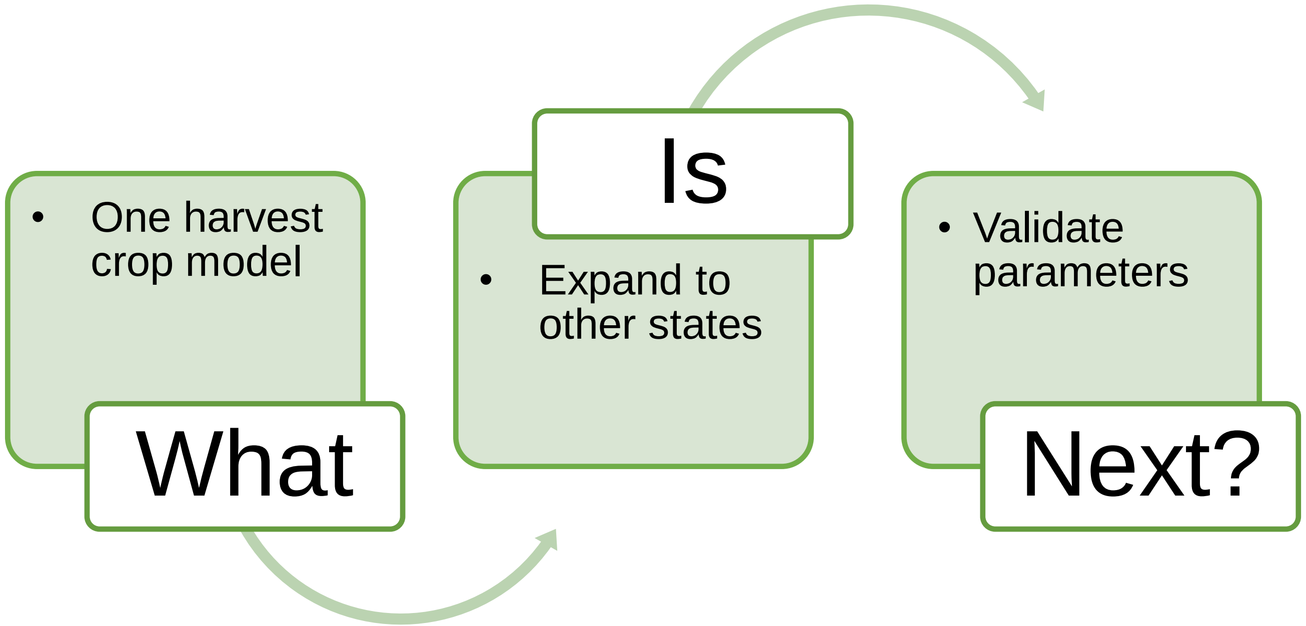
Predicted crop yield in New Mexico, Arizona and Colorado.

Clustered Planning Units

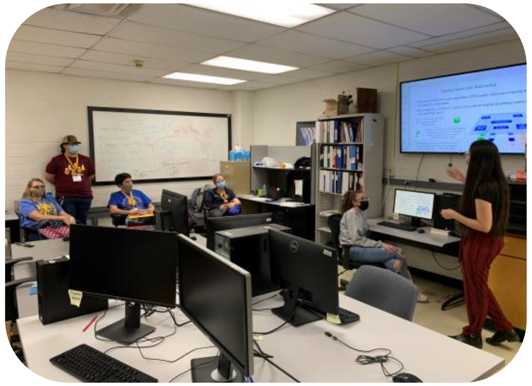
Grouped regions according to their agronomic potential in New Mexico, Arizona and Colorado.

Future Work

- Modify the yield model to consider crops that have only one harvest
- Expand yield model results to other states
- Validate some of the model parameters for each region



Acknowledgements



FFAR Officers: Lucyna Kurtyka, John Reich

ASU Team

J. Rene Villalobos
George Runger
Arnie Maltz
Pat Phelan
Rodrigo Ulloa
Xaimarie Hernández Cruz
Grace Neal
Francisca Quijada Dibarrat
Darshil Shaileshkumar Shah
Aryan Bisht
Miguel Peinado
Alexander Eierle

Former ILPIL members

Hector Flores
Omar Ahumada
Octavio Sánchez

NMSU Team

Paul Gutierrez
Madhav Regmi
Chadelle Robinson
Eric Nez

Other Partners

Jim Kallof
Patty Emmert
Paul Cordero
Duncan Family Farms
La Montañita Coop
Sol y Tierra Growers
Local First
Stern Produce
CH Robinson

ILPIL
International Logistics & Productivity Improvement Lab

FFAR

ASU Arizona State University

NM STATE UNIVERSITY

THANK YOU

J. Rene Villalobos, Ph.D.

Rene.Villalobos@asu.edu

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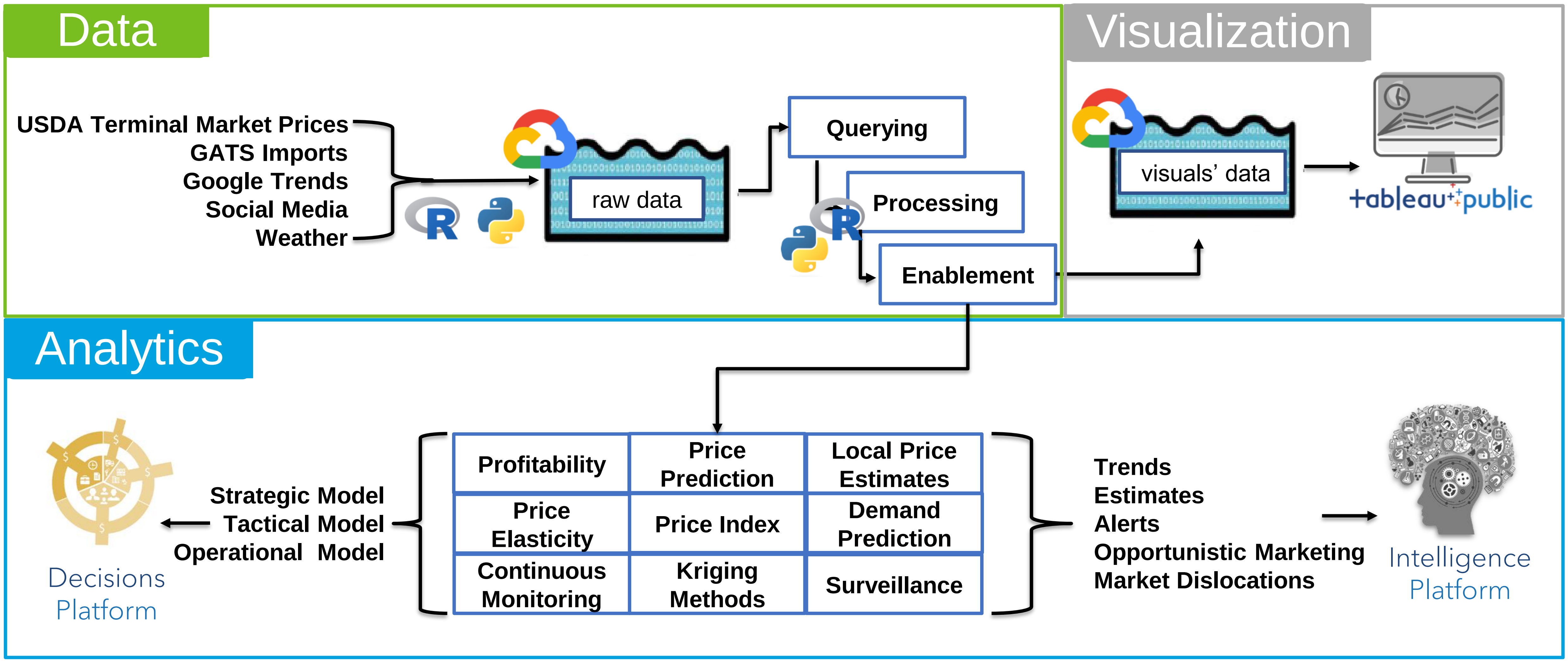
Questions? Comments?

Additional Material

Market Intelligence Interactions



Prescriptive Analytics

Yield Prediction

Usage of biological models to predict the total yield and its harvest distribution for each possible planting week.

Planning Unit Definition

Identify yield homogeneous regions.

Farm Planning

Usage of predicted prices and yields as inputs for agricultural planning optimization models.