Progress Report Meeting November 20th, 2020

Technology-Enabled, Rapid-Response Fresh Food Supply Chains (TERRa-Fresh) Workshop on Planning Tools

Facilitated by Omar Ahumada and Paul Gutierrez

Arizona State University

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Agenda

9:50 AM: Introduction to planning of the fresh agricultural supply chain, Omar Ahumada

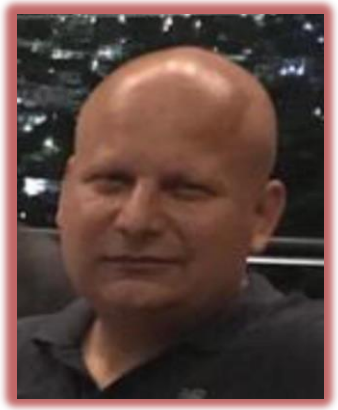
10:05 AM: Current planning tools in TERRa-Fresh, Rodrigo Ulloa

10:20 AM: Parameter setting, Rodrigo Ulloa

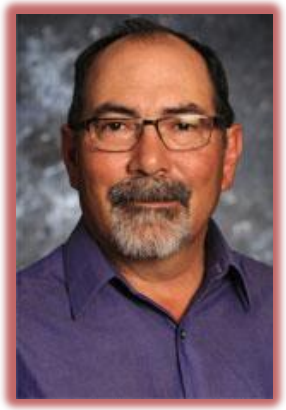
10:30 AM: Representative Farms formation and Pilot Implementation Paul Gutierrez, Patty Emmert

10:40 AM: Open discussion

Introductions



Omar Ahumada
Professor of Agribusiness
Universidad Autonoma de Occidente



Paul Gutierrez
Professor Agricultural Economics
New Mexico State University

Rodrigo Ulloa
Ph.D. Candidate, Industrial Engineering
Arizona State University

Vision

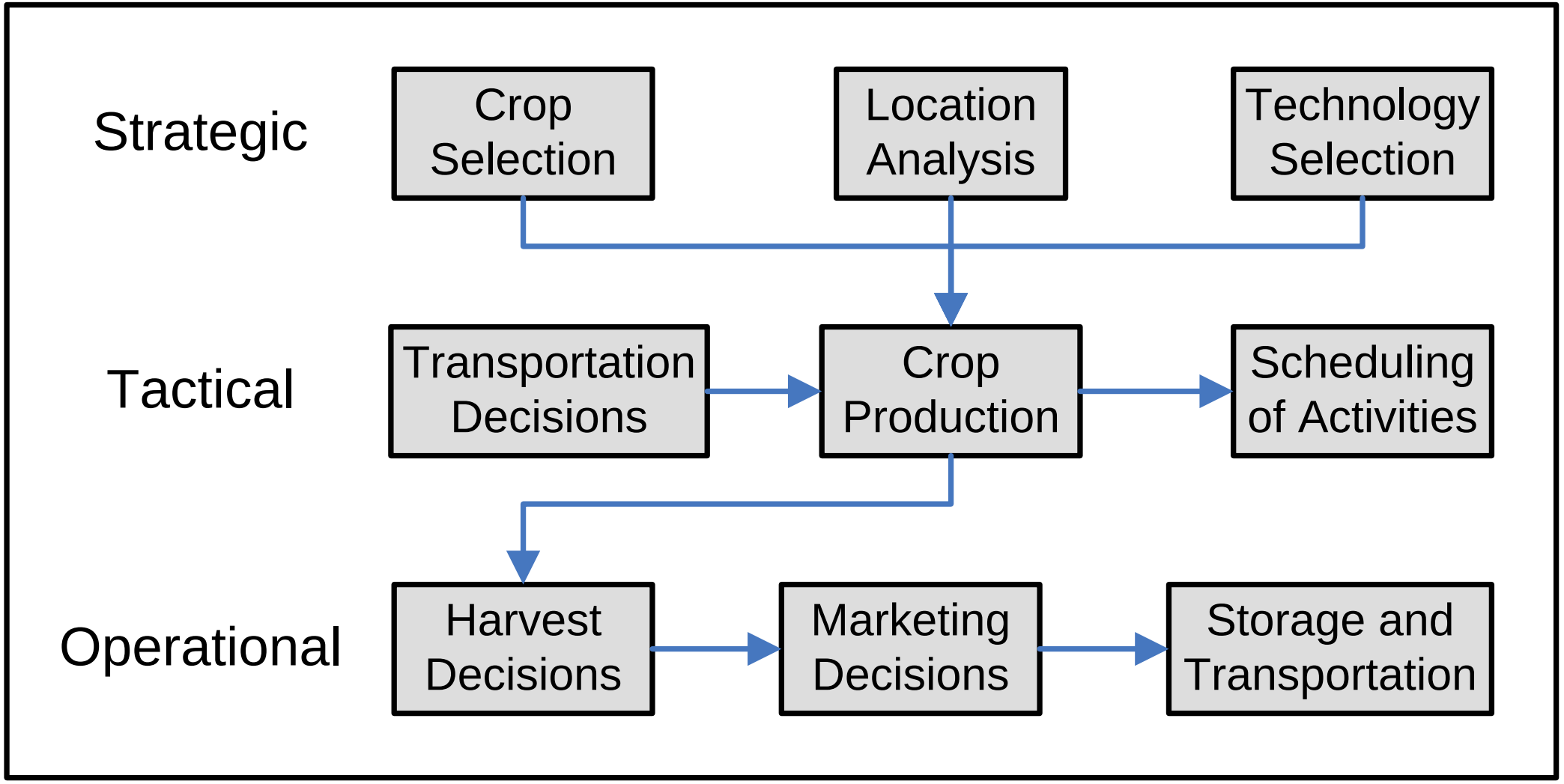
Our aim is to develop a set of **planning tools** that will support the decision-making process required for the articulation of Fresh Produce Supply Chains. These tools will assist the whole process, from the selection of **crops** and **production regions**, to the delivery of the produce to the costumers.

Planning Tools Overview

Fresh Agricultural Products:

- High production costs
- High labor requirements
- Uncertain production
- Limited shelf life
- Risky Market
  - Price unknown
  - Variable demand
- Decisions are taken before any knowledge of the demand, price and production → Planning a must

Planning Tools Overview



Current Planning Tools

- **Model 1: Land Allocation Tool**
  - Perspective of a single grower
  - Single location
  - Up to 7 crops
  - Demand based on expected prices

  → Planting and harvesting plan
  Allocates available land to selected crops

- **Model 2: Contract Response Tool**
  - Perspective of the SC articulator/buyer
  - Single location
  - Up to 7 crops
  - Demand based on a contract and expected prices

  → Planting and harvesting plan
  Plan to supply the contract demand
  Determine how much land is needed

- **Model 3: Contract Response Tool (multi-location)**
  - Perspective of the SC articulator/buyer
  - Up to 6 locations
  - Up to 7 crops
  - Demand based on a contract and expected prices

  → Planting and harvesting plan
  Plan to supply the contract demand
  Determine needed land in each region
  Takes advantage of complementary regions

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Model 1: Land Allocation Tool

- **Step 1**: Select the **Location** and its parameters

Model 1: Land Allocation Tool

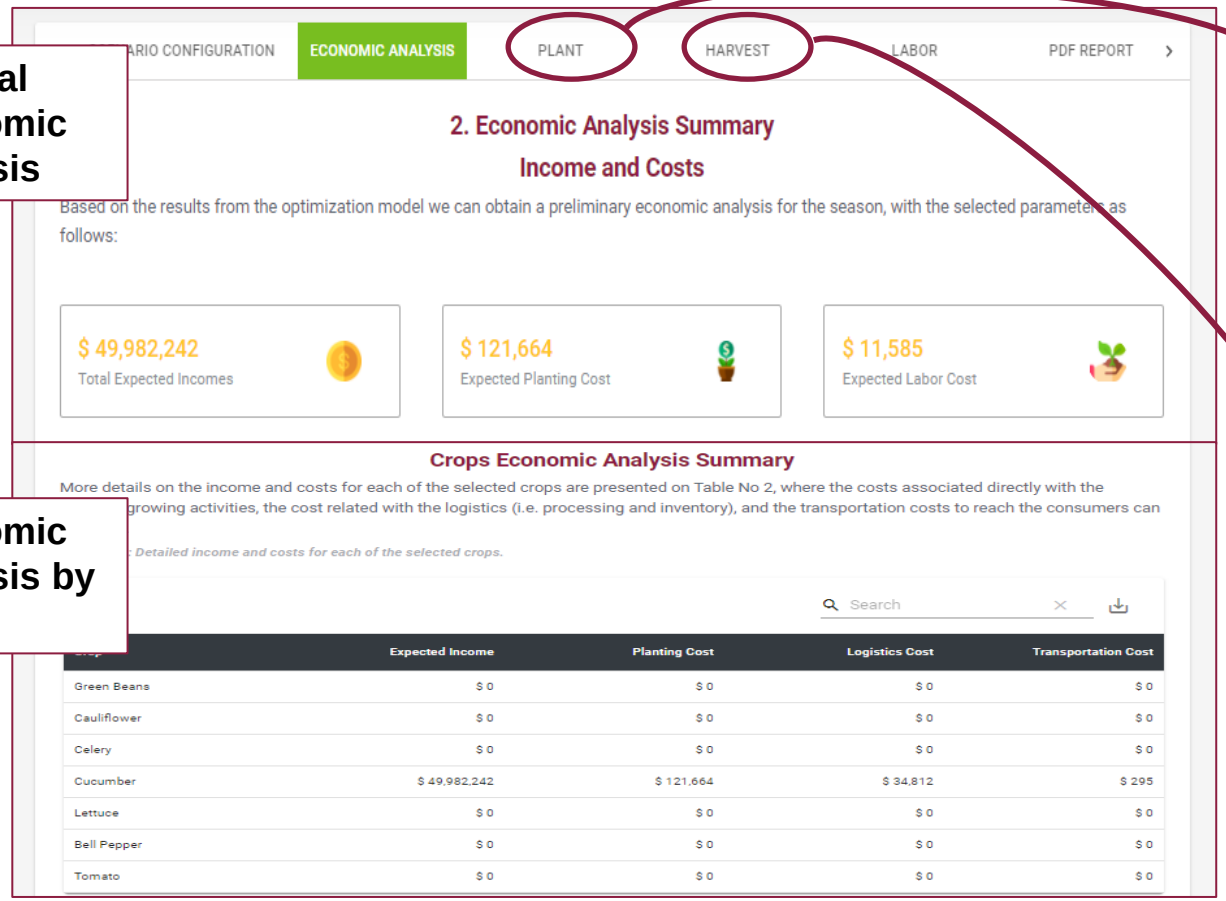
- **Step 2**: Select the **Crops** and its parameters (additional data)

Model 1: Land Allocation Tool

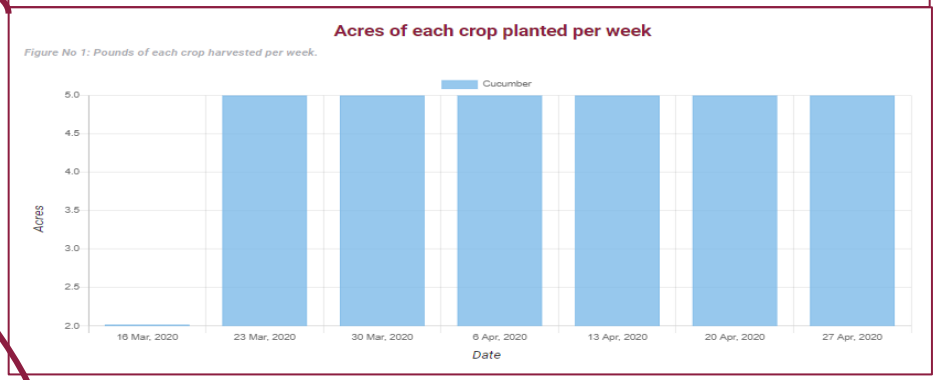
- **Step 3**: Run the Optimization to obtain the results. Here some examples of how it looks:

General Economic Analysis

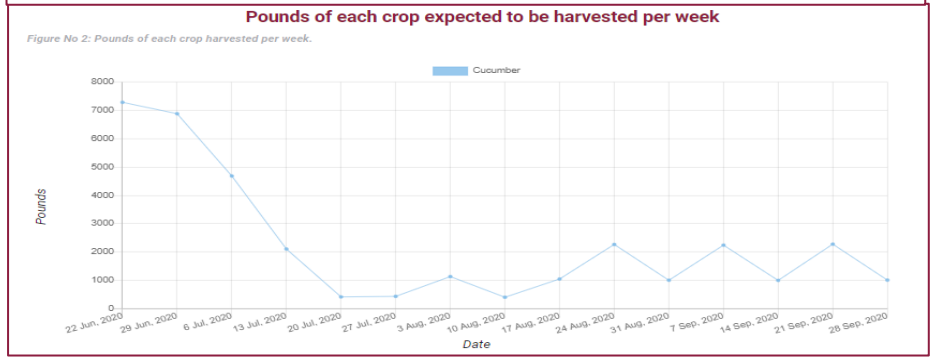
Economic Analysis by Crop



Planting Calendar (acres/week)



Harvesting Calendar (lb./week)



Tactical Planning Models

- **Model 1: Land Allocation Tool**
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- **Model 3: Contract Response Tool (multi-location)**
  - Perspective of the SC articulator/buyer
  - Up to 6 locations
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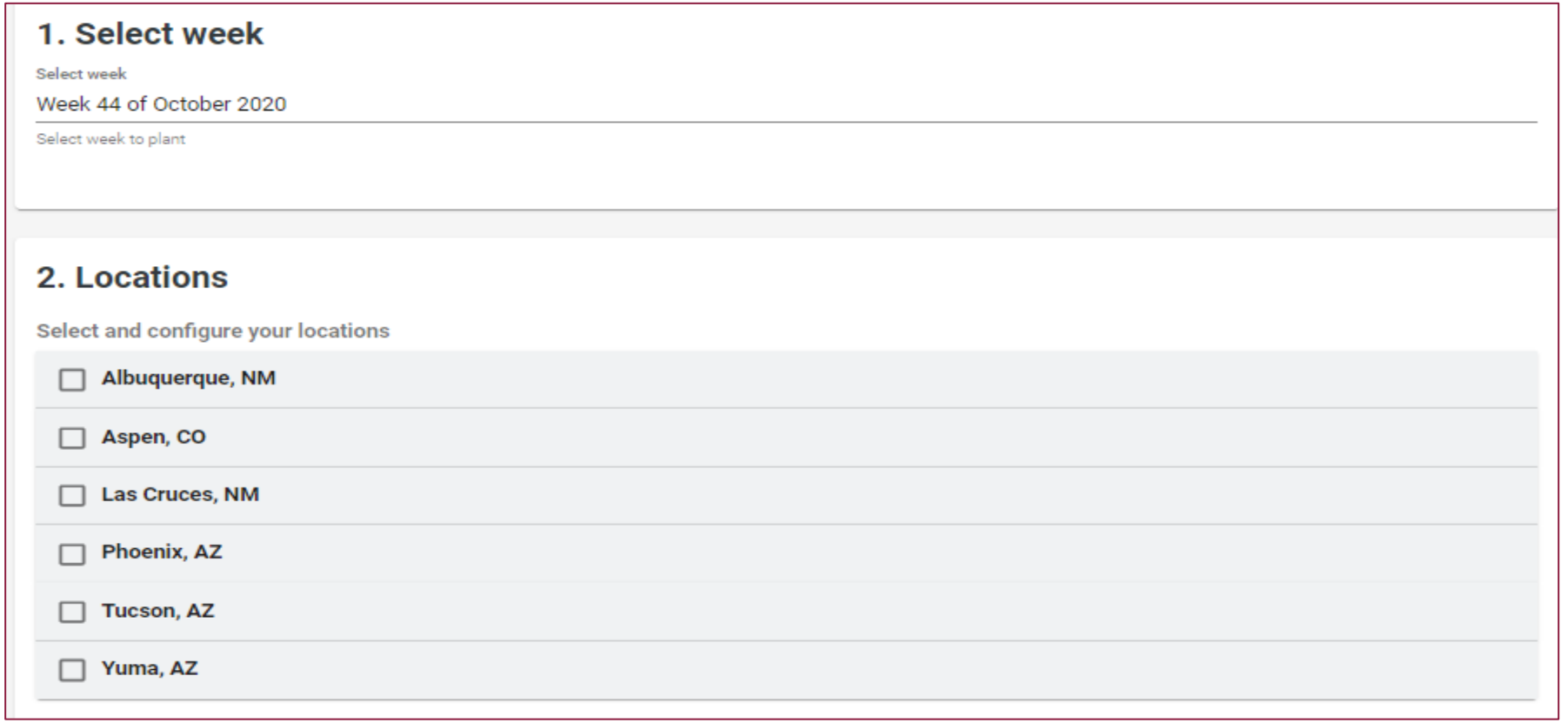
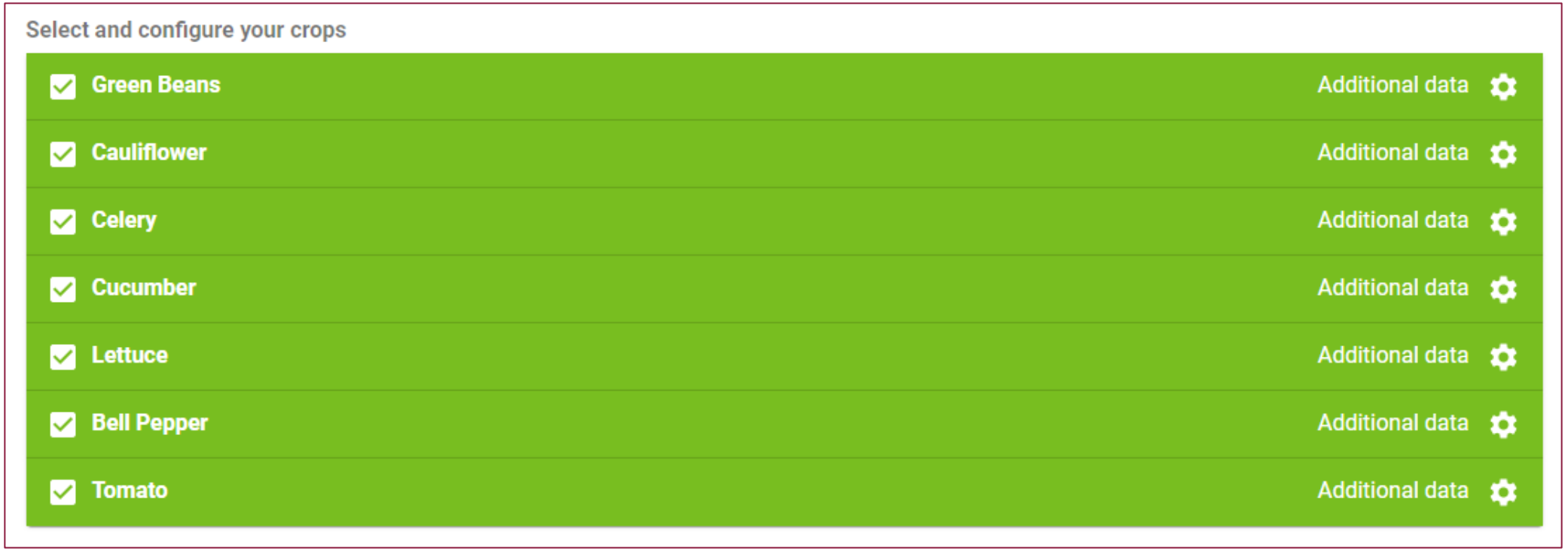
Model 3: Contract Response Tool (multi-location)

- **Step 1**: Select Planning Week and Locations



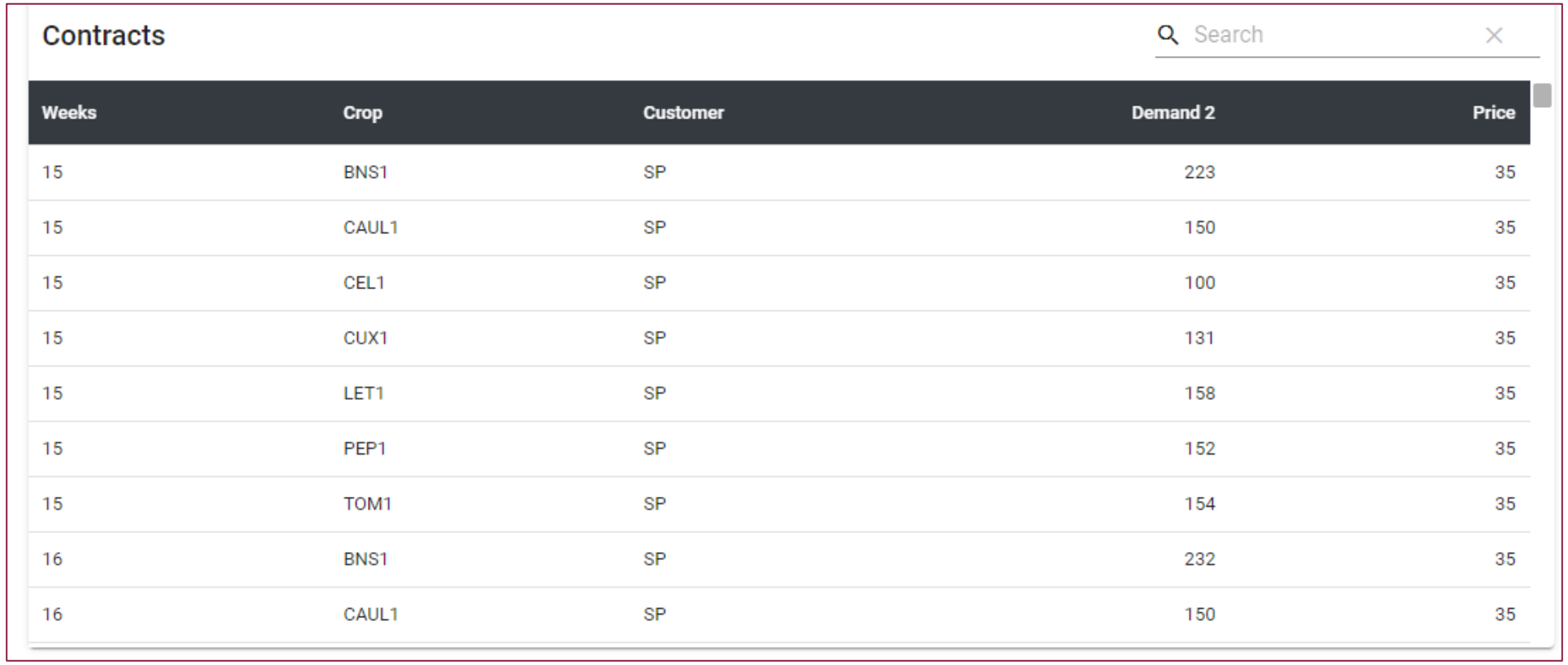
Model 3: Contract Response Tool (multi-location)

- **Step 2**: Select the **Crops** and its parameters (additional data)



Model 3: Contract Response Tool (multi-location)

- **Step 3**: Upload the **Contract** (format sample available)



Weeks	Crop	Customer	Demand 2	Price
15	BNS1	SP	223	35
15	CAUL1	SP	150	35
15	CEL1	SP	100	35
15	CUX1	SP	131	35
15	LET1	SP	158	35
15	PEP1	SP	152	35
15	TOM1	SP	154	35
16	BNS1	SP	232	35
16	CAUL1	SP	150	35

Model 3: Contract Response Tool (multi-location)

- **Step 3**: Run the Optimization to obtain the results. Here some examples of how it looks:

General Economic Analysis

2. Economic Analysis Summary

Based on the results from the optimization model we can obtain a preliminary economic analysis for the season, with the selected parameters as follows:

$ 13,316,261	$ 99,760	$ 916
Total Expected Incomes	Expected Planting Cost	Expected Labor Cost

Economic Analysis by Location

Summary by Location

A detailed breakdown of the expected income and costs for each of the selected locations is presented in Table No 1. Note that these costs are estimated based on the inputs selected by the user and the recommended decisions provided by the planning tool.

Table No 1: Detailed income and costs for each location.

Location	Expected Income	Planting Cost	Processing and Inventory Costs	Transportation Cost	Income / Acre ($/acre)	Profit / Acre ($/acre)
Albuquerque, NM	$ 1,352,127	$ 13,096	$ 505	$ 47	$ 675,343	$ 668,526
Aspen, CO	$ 744,810	$ 18,889	$ 313	$ 29	$ 155,565	$ 151,548
Las Cruces, NM	$ 6,298,835	$ 27,495	$ 3,148	$ 291	$ 631,272	$ 628,172
Phoenix, AZ	$ 2,516,098	$ 16,591	$ 1,238	$ 114	$ 428,969	$ 425,910
Tucson, AZ	$ 1,525,392	$ 16,292	$ 567	$ 52	$ 434,422	$ 429,606
Yuma, AZ	$ 878,999	$ 7,397	$ 433	$ 40	$ 348,783	$ 345,661

Model 3: Contract Response Tool (multi-location)

- **Step 3**: Run the Optimization to obtain the results. Here some examples of how it looks:

Economic Analysis by Crop

Table No 2: Detailed income and costs for each crop.

Crop	Expected Income	Planting Cost	Processing and Inventory Costs	Transportation Cost
Green Beans	$ 2,639,206	$ 17,793	$ 1,649	$ 152
Cauliflower	$ 1,067,500	$ 6,377	$ 411	$ 38
Celery	$ 1,295,000	$ 8,284	$ 499	$ 46
Cucumber	$ 3,097,215	$ 12,637	$ 1,649	$ 152
Lettuce	$ 1,732,850	$ 10,716	$ 659	$ 61
Bell Pepper	$ 1,836,690	$ 10,291	$ 716	$ 66
Tomato	$ 1,647,800	$ 33,662	$ 622	$ 57

Model 3: Contract Response Tool (multi-location)

- **Step 3**: Run the Optimization to obtain the results. Here some examples of how it looks:

Land Usage at each Location

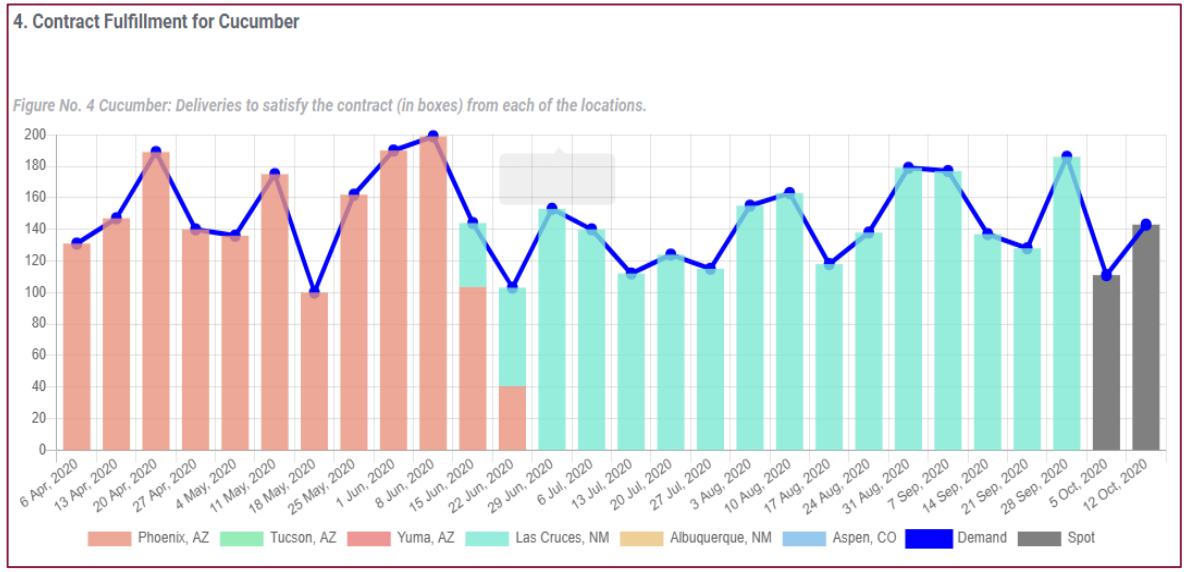
Table No 1: Total land usage by location.

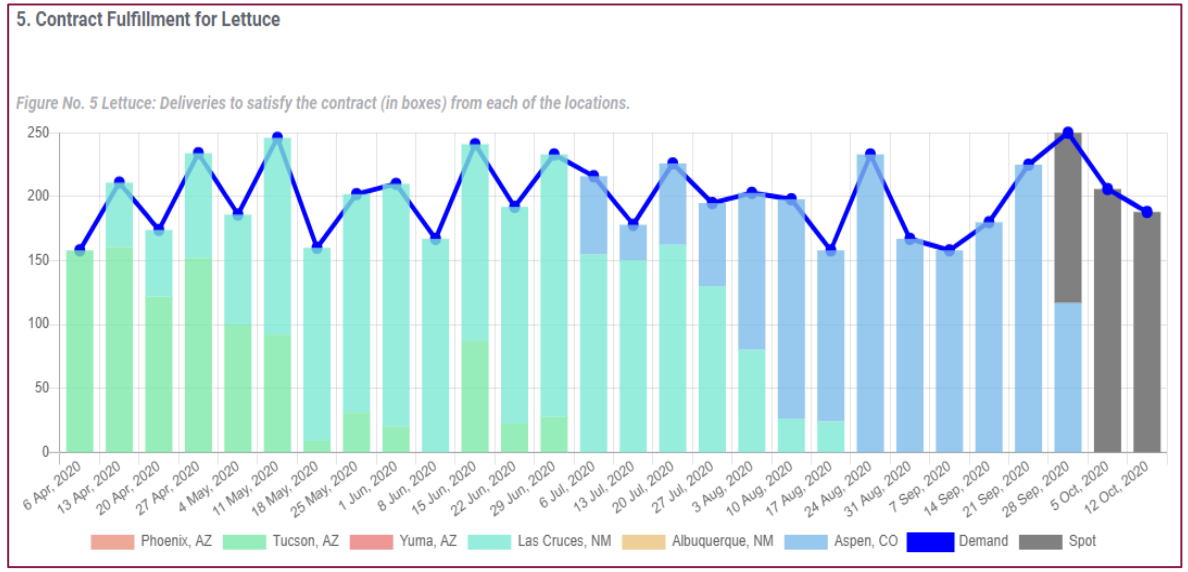
Location	Land Recommended (Acres)
Albuquerque, NM	2.00
Aspen, CO	4.79
Las Cruces, NM	9.98
Phoenix, AZ	5.87
Tucson, AZ	3.51
Yuma, AZ	2.52

Model 3: Contract Response Tool (multi-location)

- **Step 3**: Run the Optimization to obtain the results. Here some examples of how it looks:

Contract Fulfillment for each crop, from the different locations





Model 3: Contract Response Tool (multi-location)

- **Step 3**: Run the Optimization to obtain the results. Here some examples of how it looks:

Planting Calendar for each Location (acres/week)

4. Recommended Planting Decisions to Las Cruces, NM

One of the main outcomes of the optimization model, based on the selected parameters, is the plating calendar for the season. This corresponds to how the available land should be allocated, in particular the model provides a recommendation on how many acres of each product should be planted each week of the planting season.

Land Allocation

The summary of the total acres planted for each crop is presented in Chart No 1 and Table No 1 below, with the percentage of the land that is allocated to each of these products. Below, in Figure No 1, a planting calendar by week is presented indicating how many acres are recommended to be planted during the planting season. Table No 3, shows the detailed planting calendar for each of the crops.

Chart No 1: Land allocation distribution to each crop.

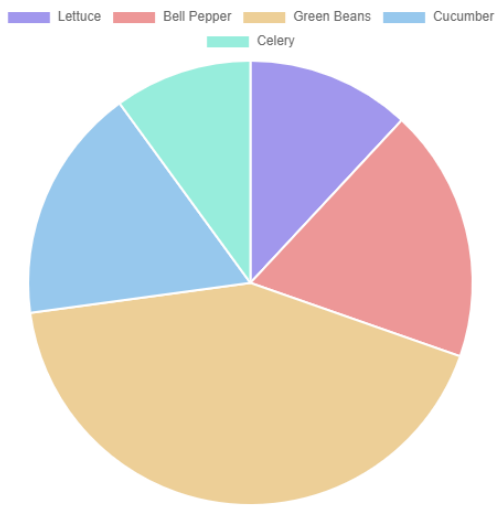


Table No 1: Summary of planted acres per crop.

Crop	Total Acres Planted	Percentage of Land Used
Lettuce	1.19	11.92%
Bell Pepper	1.84	18.49%
Green Beans	4.24	42.48%
Cucumber	1.71	17.09%
Celery	1.00	10.02%

Model 3: Contract Response Tool (multi-location)

- **Step 3**: Run the Optimization to obtain the results. Here some examples of how it looks:

Harvesting Calendar for each Location (lb./week)

5. Expected Harvesting Volumes for Las Cruces, NM

A second output of the optimization model is the expected harvesting calendar corresponding to the planting decisions recommended above. This result is detailed below, corresponding to how many pounds of each product are expected to be harvested based on the planting decisions presented in the previous section.

Expected Harvesting Volumes

The summary of the total pounds expected to be harvested for each crop is presented in Chart No 1 and Table No 1 below. Figure No 1 presents a weekly calendar that indicate how many pounds are expected to be harvested during each week of the harvesting season. These values corresponds to the expected yields of the planting decisions presented in the previous section. Table No 2 shows the detailed harvesting calendar for each crop.

Chart No 1: Harvesting volumes distribution.

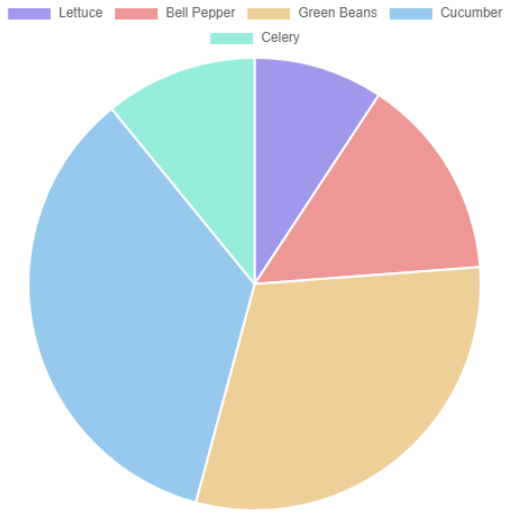


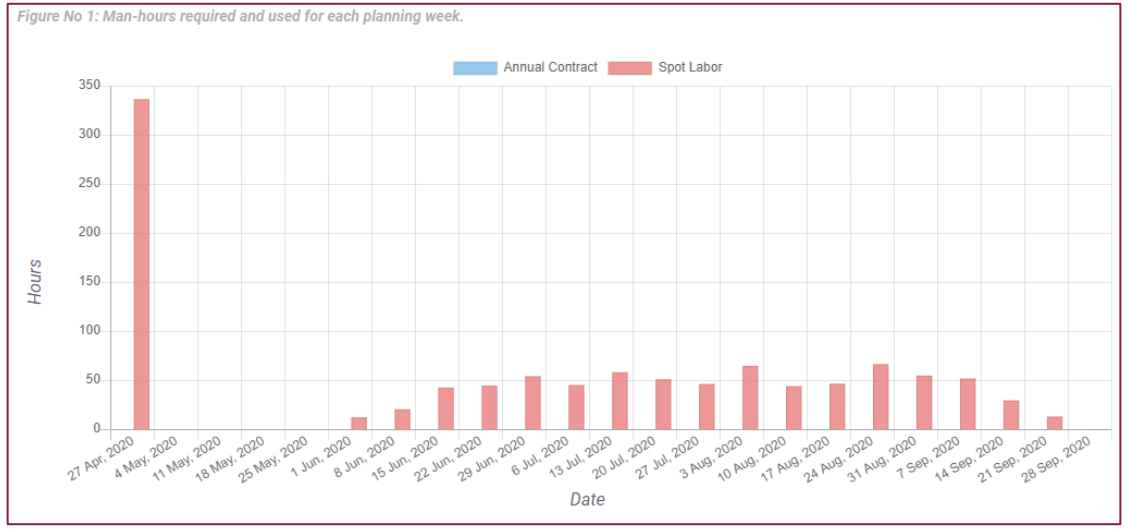
Table No 1: Summary of Harvesting Volumes.

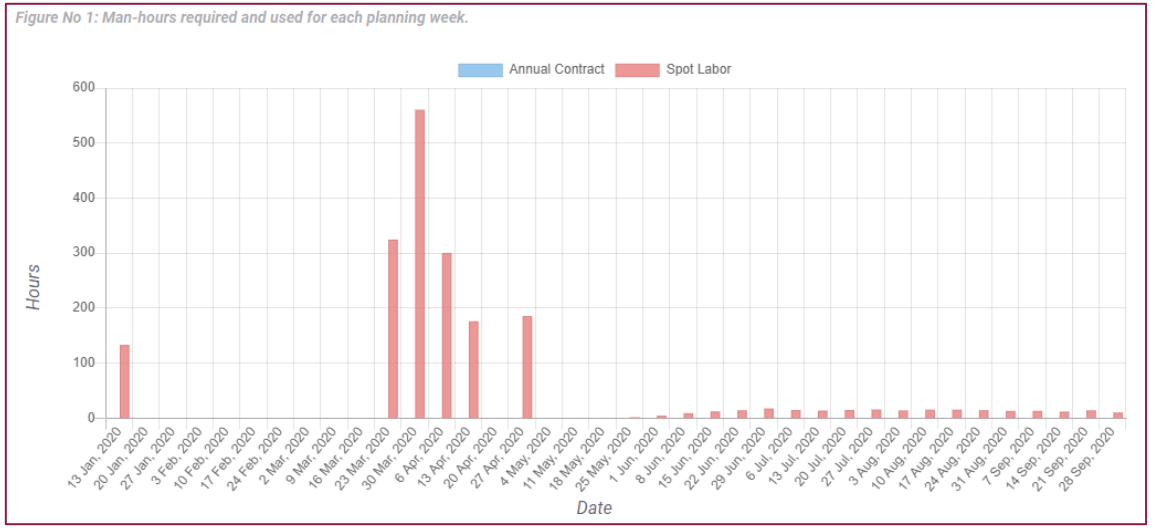
Crop	Pounds (lb.)	Percentage
Lettuce	23,595 lbs	9.26%
Bell Pepper	37,046 lbs	14.54%
Green Beans	77,404 lbs	30.39%
Cucumber	88,929 lbs	34.91%
Celery	27,754 lbs	10.90%

Model 3: Contract Response Tool (multi-location)

- **Step 3**: Run the Optimization to obtain the results. Here some examples of how it looks:

Labor requirements for each location (planting and harvesting activities)





Parameter Setting

- All the parameters used by default are estimated values. We tried to capture most relevant parameters, but there is still some work to do in refining the parameters
- This can be **changed/customized** to different users:
  - Individual Growers
  - Groups of Growers
  - Agents looking for coordination (ie: a response to Farm to School Program)
  - Supply Chain Articulator

Representative Farms formation and Pilot Implementation

Representative Farms formation and Pilot Implementation

Assessment Methodology:

- Grower specific information
- Land/Climate Zone Information
- Crop Specific Information
- Financial Services and Business Practices
- Marketing Practices
- Logistic Service Provider Information
- Regulations

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Representative Farms formation

Grower Specific Information:

- Land Ownership and Land size
- Expertise of growers
- Business Model
- Capital Source
- Level of Association
- Infrastructure related to growing fresh produce, precooling, processing, packaging

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Representative Farms formation

Land/Climate Zone Information:

- Temperature
- Precipitation
- Amount of Sun Light
- Quality of soil
- Water availability
- Humidity
- Etc.

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Representative Farms formation

Crop Specific Information

- Production costs, labor and water requirements
- Yield Estimations
- Compatibility Requirements (Temperature and Chemical)
- Storage Requirements
- Shelf Life

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Representative Farms formation

Comprehensive Enterprise Analysis of Each Crop:

Carrots

Number of Crop Acres	Total Cost per Acre	Total Crop Cost
30	$ 4,672.54	$ 140,176.05

Yield	Pounds Per Ac	Total Production
Estimated Amount Harvested	7,000.00	210,000.00

Acre	Per Acre	Total Crop Sales
Price per Pound	$ 1.50	$ 1.50
Gross Farmers Market Sales	$ 10,500.00	$ 315,000.00
Net Profit Wholsale Market	$ 5,827.46	$ 174,823.95

Net Profit at % of Crop Sold	80%	60%	40%
Per Acre	$ 3,727.46	$ 1,627.46	$ (472.54)
Total	$ 111,823.95	$ 48,823.95	$ (14,176.05)

Total Acres =

Total Cost/Operat	Per Acre	Total
Land Prep Total	$ 822.87	$ 24,686.17
Planting Total	$ 360.76	$ 10,822.69
Cultivation Total	$ 737.47	$ 22,124.02
Harvest Total	$ 2,751.44	$ 82,543.17
Post Harvest Total	$ -	$ -
Total	$ 4,672.54	$ 140,176.05

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Additional Questions
&
Open Discussion

Sponsors

Completed:

- Omar Ahumada, Ph.D. Dissertation
- Octavio Sánchez, M.S. Thesis
- Hector Flores, M.S. Thesis
- Nicholas Mason, Ph.D.
- Christopher Wishon, Ph.D.
- Hector Flores, Ph.D.

In Progress:

- Rodrigo Ulloa, Ph.D.
- Xaimarie Hernández Cruz, Ph.D.
- Grace Neal, B.S.

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Additional Material