Terra-Fresh

Unveiling Technology-Enabled, Rapid-Response Fresh Food Supply Chains

November 20th, 2020

J. Rene Villalobos
International Logistics and Productivity Improvement Laboratory
Arizona State University

http://ilpil.asu.edu, www.terra-fresh.com

Arizona State University

FFAR

NM STATE UNIVERSITY

ILPIL
International Logistics & Productivity Improvement Lab

AGENDA

- **Introduction of event**
- Event Schedule
- Background
- TERRa Fresh Introduction and Demo
- Other Activities
- Conclusions and Introduction to workshops

Introductions

J. Rene Villalobos
Associate Professor of Industrial Engineering
Arizona State University

Patrick Phelan
Professor of Mechanical & Aerospace Engineering
Arizona State University

George Runger
Professor of Industrial Engineering
Arizona State University

Paul Gutierrez
Professor Agricultural Economics
New Mexico State University

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

Xaimarie Hernandez
Ph.D. Student, Industrial Engineering
Arizona State University

Goals of the event

- Present the objectives and impact of the project funded by FFAR
- Introduce the Concept of Technology-Enabled, Rapid-Response Fresh Food Supply Chains (TERRa-Fresh)
- Demonstration of a prototype of TERRa-Fresh
- Next steps and introduction to workshops

AGENDA

- Introduction of event
- **Event Schedule**
- Background
- TERRa Fresh Introduction and Demo
- Other Activities
- Conclusions and Introduction to workshops

Activities for today

8:30 – 9:45 AM **Introduction of TERRa-Fresh and summary of tools developed.**
Lead: Rene Villalobos
Zoom Link: https://asu.zoom.us/j/82868098308

9:50 – 10:45 AM **Workshop on planning and coordination tools for fresh fruits and vegetables.**
Facilitated by Paul Gutierrez and Omar Ahumada
Zoom Link: https://asu.zoom.us/j/89438758955

9:50 – 10:45 AM **Workshop on Market Intelligence.**
Facilitated by George Runger and Hector Flores
Zoom Link: https://asu.zoom.us/j/84135179486

9:50 – 10:45 AM **Workshop on Cold Chain issues and mini-containers.**
Facilitated by Pat Phelan and Jim Kallof
Zoom Link: https://asu.zoom.us/j/83865883671

9:50 – 10:45 AM **Workshop conclusions.**
Facilitated by Arnie Maltz
Zoom Link: https://asu.zoom.us/j/82809504308

AGENDA

- Introduction of event
- Event Schedule
- **Background**
- TERRa Fresh Introduction and Demo
- Other Activities
- Conclusions and Introduction to workshops

Motivation on Fresh Fruits and Vegetables

Fresh Fruits & Vegetables (FFV) are the **cornerstone of healthy diets worldwide.**

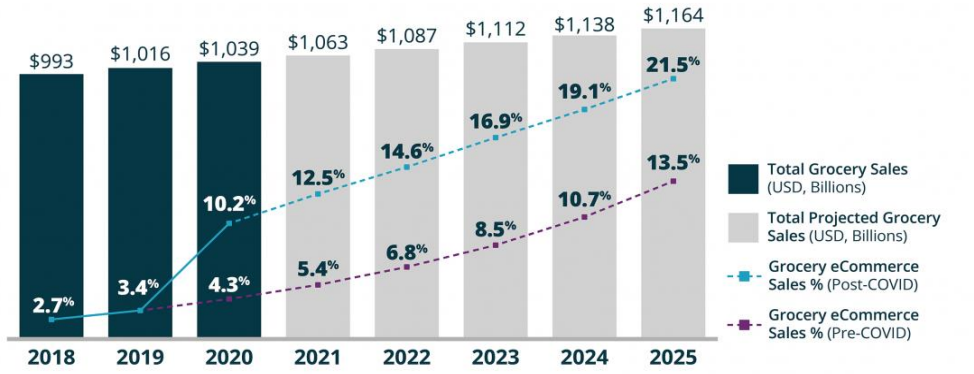
They form the core of **local food and grass roots movements.**

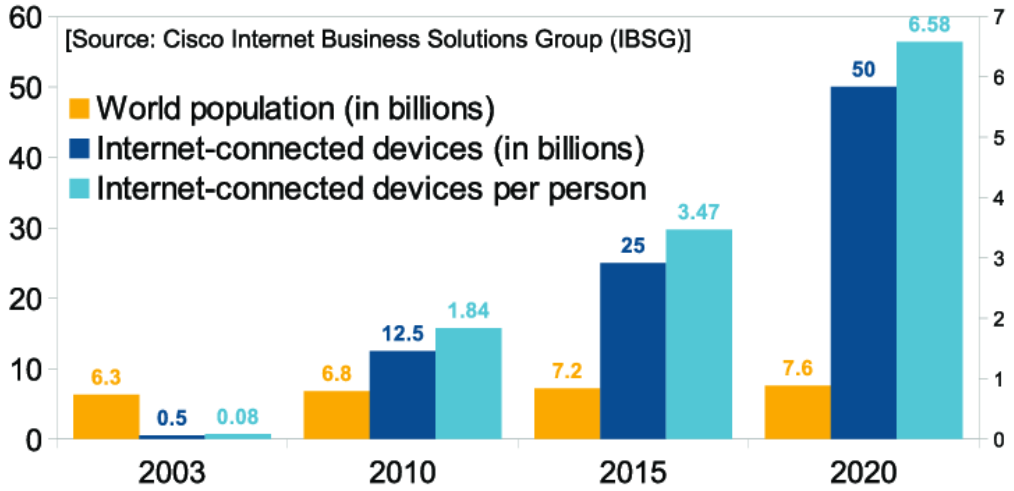
They present important opportunities for **small growers for attracting new growers.**

Some challenges need to be sorted to take on these opportunities.

Technologies and strategies

- E-commerce and pick-up of orders (almost every grocery store).
- Sharing economies (uber eats, uber freight).
- Smart Appliances (order placing refrigerators).
- Real time information (POS, social networks).
- **E-commerce and direct delivery of orders (Amazon, Instacart).**
- **Real time information and sensors (harvest, traceability, inventory levels).**





Can we use these technologies to build supply chains to make lean, direct connections between growers and consumers?

The Vision of the FFAR Project

- **Build** information-rich, opportunity discovery, decision-making environments that **enable small farmers to sale directly their products in the most attractive markets.**
- **Leverage**, the real-time information from all the echelons of the supply chain obtained **by sensors and new information technologies.**
- **Capture optimal value** for the SC stakeholders such as **the grower,** the final customer, the retailer and **the environment.**
- **Propagate** market responsive SC based on **demand-pull** instead of the current **supply-push** strategies.

AGENDA

- Introduction of event
- Event Schedule
- Background
- **TERRa Fresh Introduction and Demo**
- Other Activities
- Conclusions and Introduction to workshops

TERRa-Fresh

TERRa-Fresh stands for:

Technology-**E**nabled **Ra**pid-**R**esponse **Fresh** supply chains

- It is an integrated **planning, analytics, coordination and marketplace environment** that seeks to exploit the new technological realities for the benefit of the **growers**, the **consumers**, and the **environment**.
- It enables market-oriented supply chains based on the effective utilization of **market intelligence**, information technology, **negotiation, coordination, and planning** decision support tools.
- It **shortens** the **SC distance** between growers and **emerging market opportunities.**

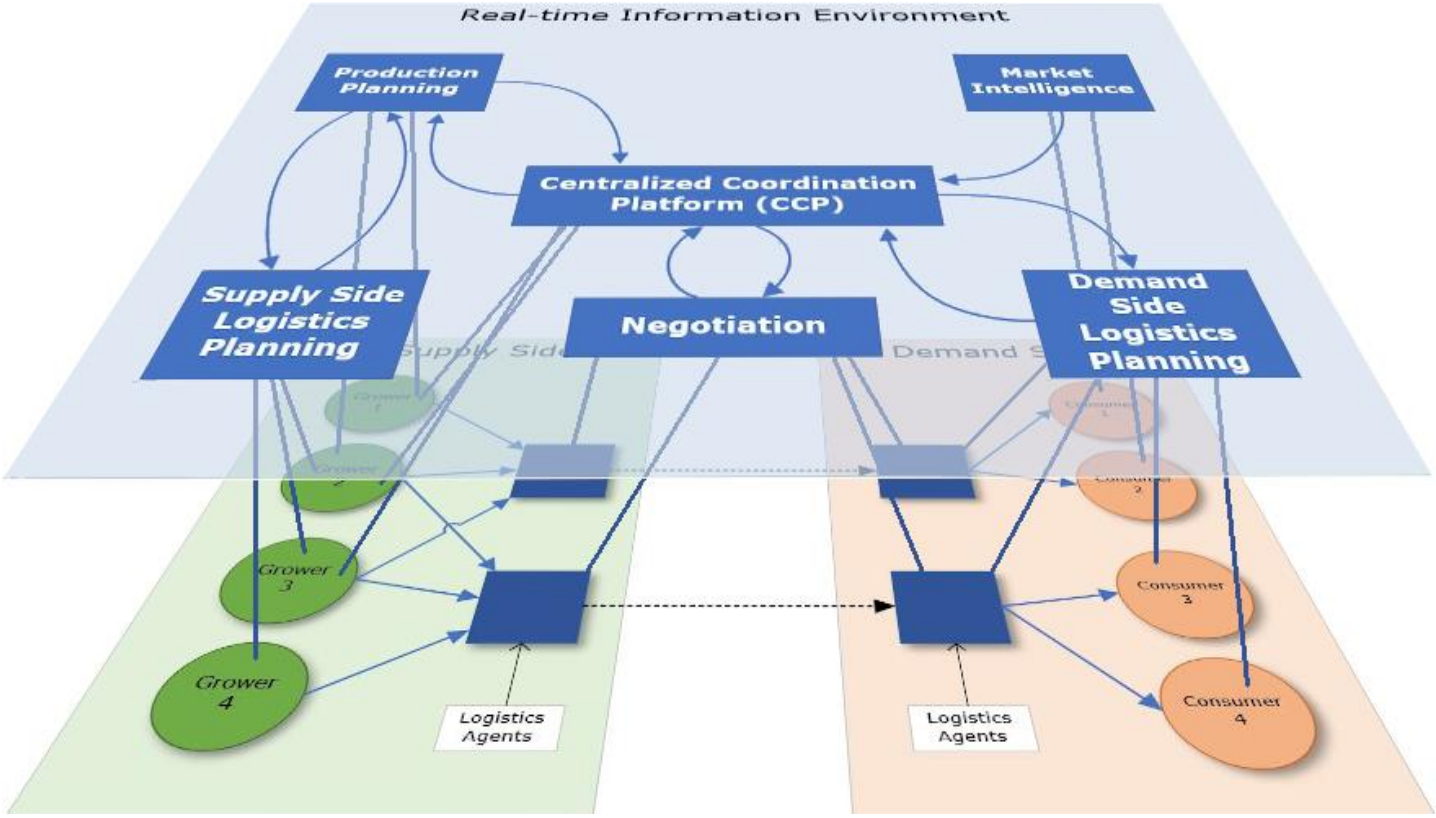
Core TERRa-Fresh strategies

- Implement a connected **multi-module** platform onto which **market intelligence and supply chain planning tools** will be hosted, enabled, and solutions deployed in the form of short supply chain designs.
- Explore and construct **automated logistics planning, monitoring and coordination tools** for the efficient operation of supply chains.
- Build **open access systems** that are adaptable, scalable, transparent and promote verifiable traceability.
- Empower logistics agents **working on behalf of the growers and consumers** known as supply chain articulators.
- Create a marketplace to attract **risk capital to fund the formation of virtual enterprises.**

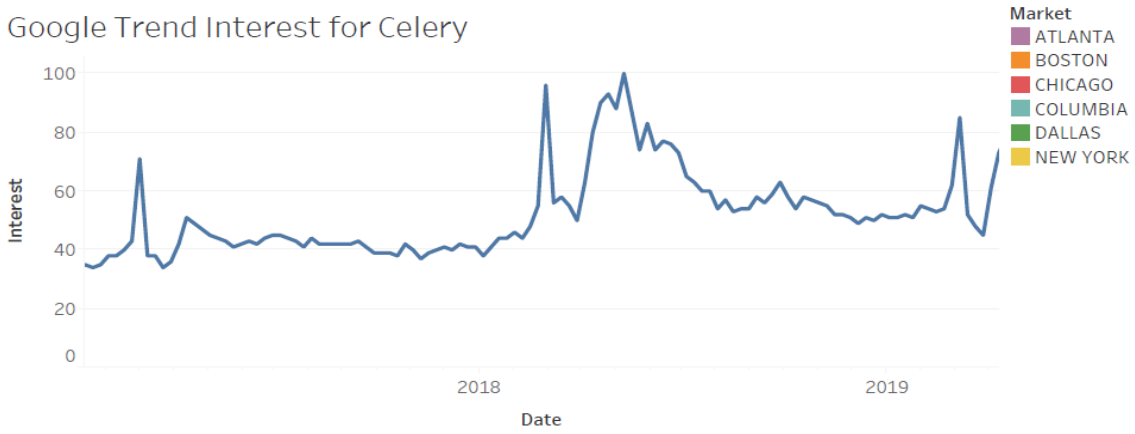
Segmentation of the Problem

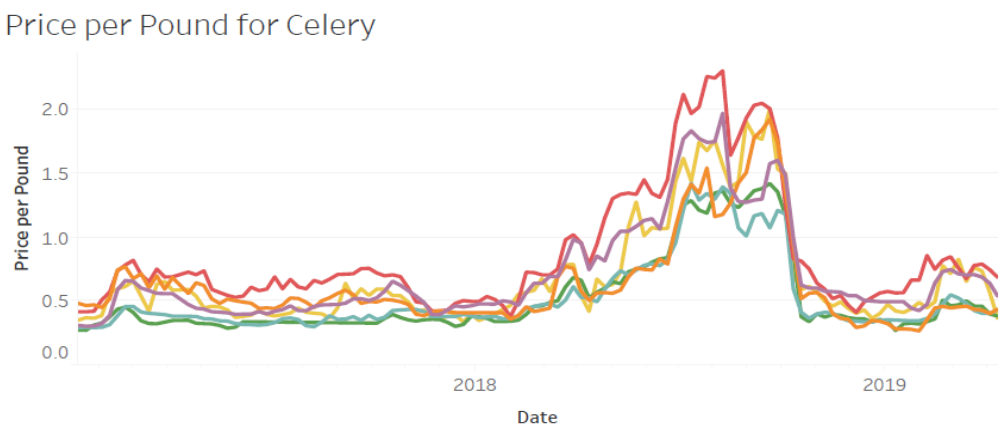
Steps:

1. Opportunity is identified.
2. The potential players are identified.
3. The logistics agents put together the specific teams in the supply and demand sides, along with production plans.
4. Final implementation takes place.



Example of a Latent Opportunity



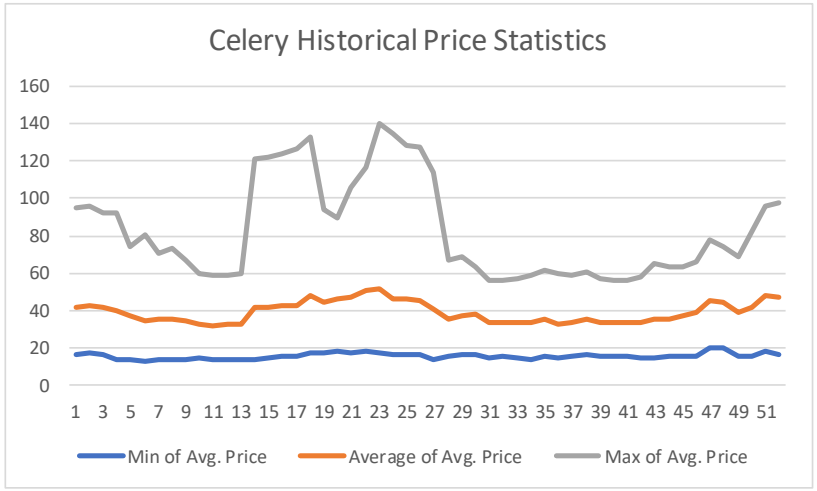


At the beginning of 2018 there was an **increase of interest and demand for celery and celery juice** which **led to an increase of celery prices** across the US markets.

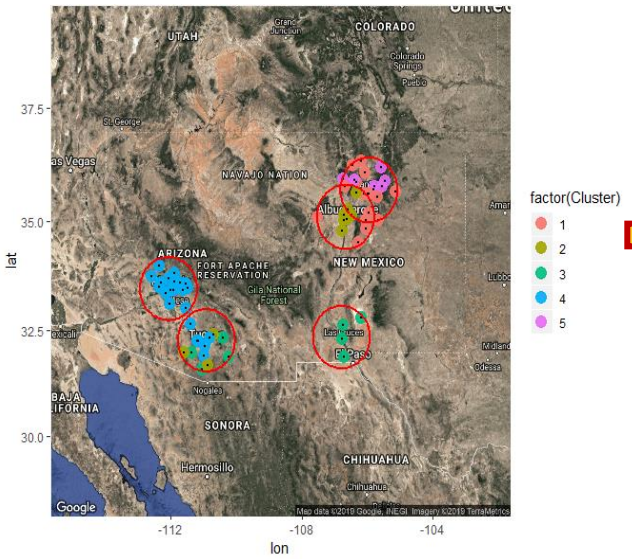
If grower's had access to **information** that reflected this increase in demand and prices, **they could have benefitted from this opportunity.**

Decision Support Stages

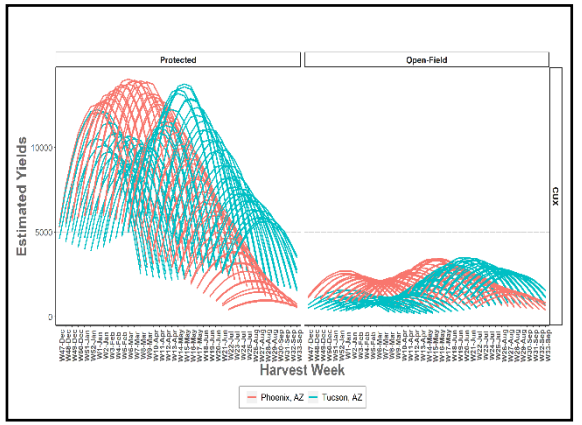
Projected Prices



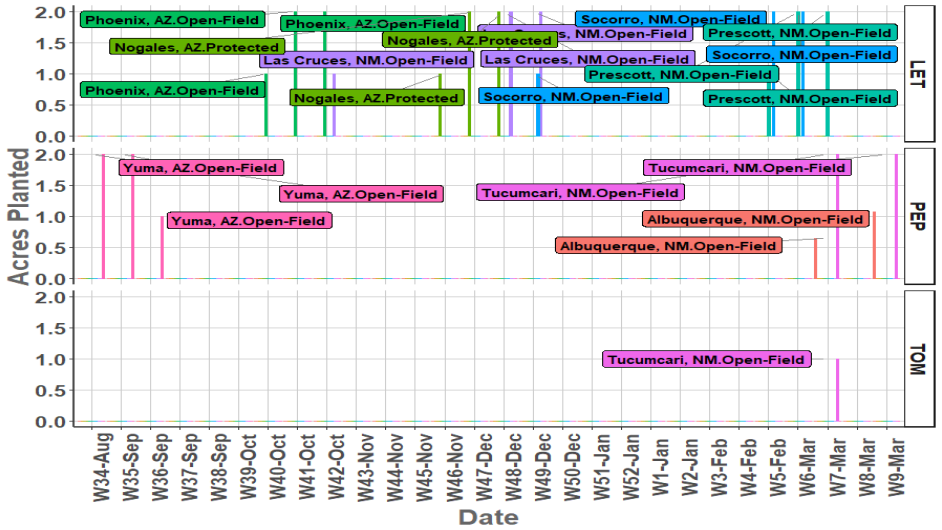
Potential Growing Regions



Expected Yields



Production Decision and Allocation



Planning Tools (Planting/Harvesting Decisions)

Objective:

$$Max = \sum_{tki}(\sum_{f} SC_{tkfir} + \sum_{h}\sum_{w} SW_{htkwir} + \sum_{h}\sum_{d} SD_{htkdir}) \cdot price_{tki} + \sum_{hj} SK_{hj} Psalv_{j}$$
$$- \sum_{pjl} Plant_{pjl} Cplant_{jl} - \sum_{pjl} Opl_{tl} \cdot CLabor - \sum_{tl} Hire_{tl} \cdot Chire - \sum_{tl} Opt_{tl} \cdot Ctemp$$
$$- \sum_{tf} Opf_{tf} Chire - \sum_{tkw} Z_{tkw} \cdot Pavg_{tk} - \sum_{fhk} Pack_{hfk}(Ccase_{k} + Coper_{k})$$
$$- \sum_{tkw} Invw_{tkw} Chw_{kw} - \sum_{tkd} Invd_{tkd} Chd_{kd}$$
$$- \sum_{tkqfir} SC_{tkqfir} CT_{fir} - \sum_{htkqwir} SW_{htkqwir} CTW_{wir} - \sum_{htkqdir} SD_{htkqdir} CTD_{dir}$$
$$- \sum_{htkqfdr} SPD_{htkqfdr} CTPD_{fdr} - \sum_{htkqwdr} SWD_{htkqwdr} CTWD_{wdr} - \sum_{htkqfwr} SPW_{htkqfwr} CTPW_{fwr}$$

$$- \sum_{tkqfir} SC_{tkqfir} price_{tki} Time_{fir} / SL_{k} - \sum_{htkqwir} SW_{htkqwir} price_{tki} TimeW_{wir} / SL_{k}$$

Main steps of the SC construction process

Discovery of market opportunity

Prediction of prices, volumes, location and timing of the opportunity

Determination of the "technical" feasibility of the opportunity

Based on agronomic and logistics conditions, identification of potential complementarity regions and partners to respond to opportunity

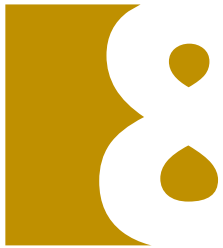
Determination of the financial feasibility of the opportunity

Advertising of opportunity and expected return to potential investors

Identification of investors and associated financial resources

Vetting and refinement of identified opportunity

Formation of virtual enterprise to capture opportunity



Identification of key supply chain articulators

Deployment of planning, monitoring, improvement and supply chain recovery tools

Introduction to demo

www.terra-fresh.com

Some functionality features

- Virtual Enterprise (coops) formation.
- Supply Chain Articulator (coordination).
- Attraction of external risk capital.
- Traceability.
- Reconfigurability based on real-time data.

AGENDA

- Introduction of event
- Event Schedule
- Background
- TERRa Fresh Introduction and Demo
- **Other Activities**
- Conclusions and Introduction to workshops

Problems in Local Logistics: Small Grower Perspective

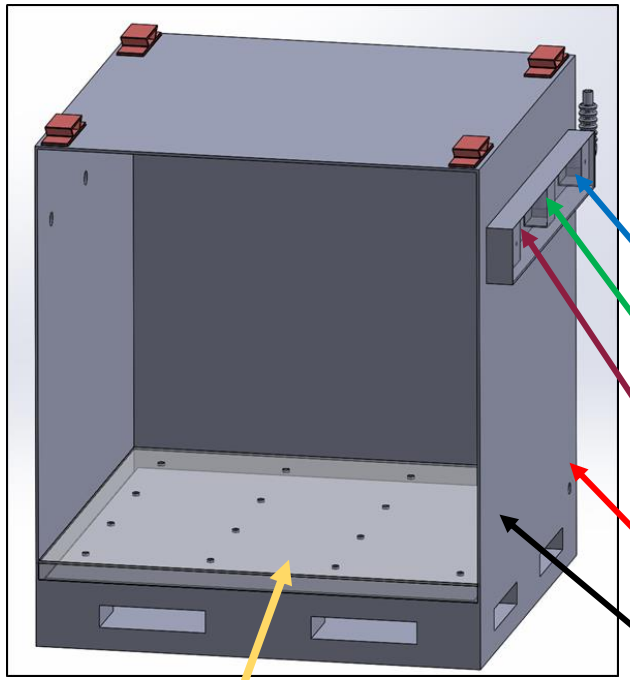
CURRENT SITUATION

- Lack of logistics capacity and service providers
- Lack of open-access facilities for processing, packing, pre-cooling, and cold storage
- Lack of critical mass for an individual grower to access efficient logistics
- Aggregation of products from different growers in a vehicle difficult because of regulations and incompatibility of products
- Lack of platforms to make an efficient demand-supply match
- **Not ready for new market conditions**

OUTLINE OF SOLUTIONS

- Access to efficient and low-cost first-mile logistics by aggregating products from different growers to reach critical masses while meeting regulations, no cross-contamination, shelf life preservation, etc.
- Utilize/Develop tools for coordinating the production of different growers for efficient aggregation of products
- Develop services to interface the small farmer directly to the market

Out-of-the-Box Solution for Problem: A Box, the Mini-Container



Cold Air Supply

Humidity Supply

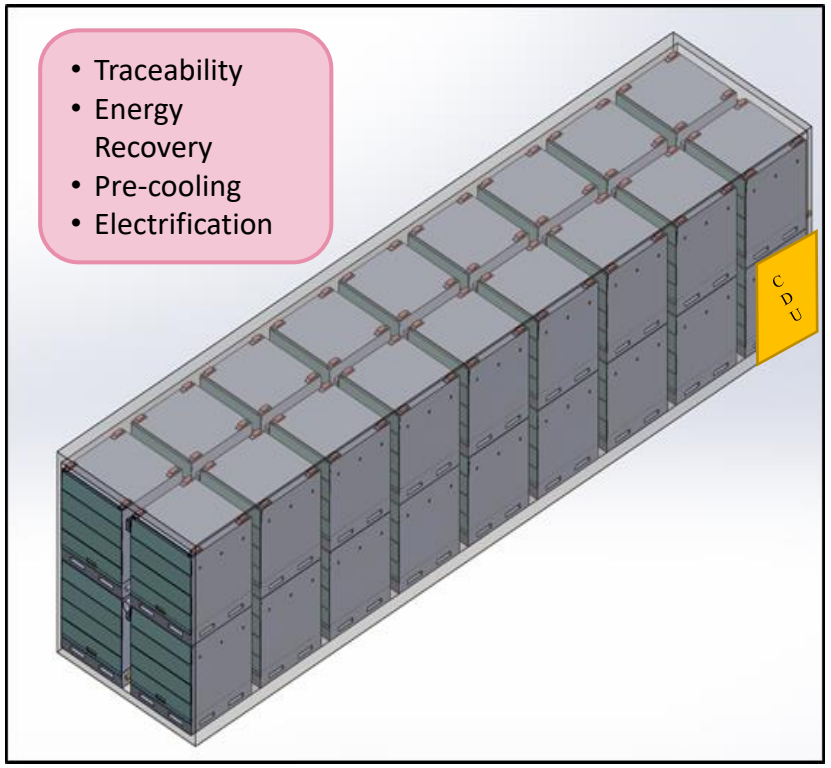
N_2 Supply

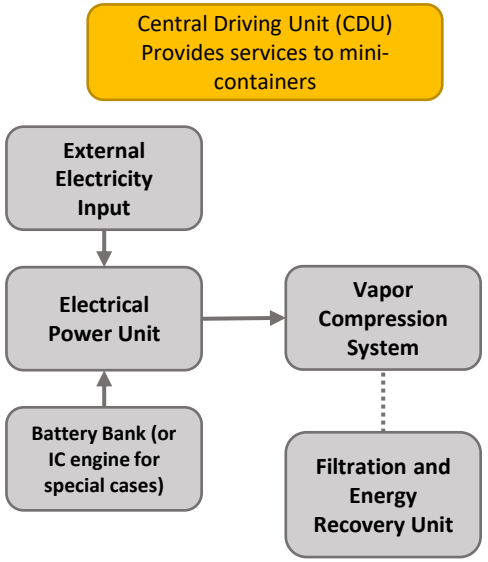
Return Air

Water/Debris Collection Area

Sensor/Traceability module Inside

- Temperature, RH, CO_2
- Ethylene, Vibration
- **Transmission/monitoring in real time of location and environmental conditions**
- **Unique ID for traceability purposes**





U.S. Provisional Patent Application No. 63/039,279, filed June 15, 2020, entitled "Systems, Methods, and Apparatuses for Implementing Aggregable, Environment-controlled Mini-Containers for the Efficient Logistics of Perishable Products."

Research Areas

Market intelligence

Planning tools

System level design

Development of predictive and prescriptive analytics tools for market intelligence:

- Data gathering from currently relevant and latent sources
- Identify opportunities
- Assess opportunities
- Present opportunities to farmers, SC stockholders and potential external investors
- Identify regions and farmers with response capacity to opportunities and being part of a common (virtual) enterprise
- **Identify conditions of vulnerability of the SC**
- **Maintain continuous surveillance of the conditions of the SC**

Research Areas

Market intelligence

Planning tools

System level design

Development and Adaptation of decision support tools:

- Assess feasibility for capturing identified opportunities
- Determine investment level and associated risk with opportunity
- Match making between opportunities and investors
- Planning and negotiation platforms for location and allocation of opportunities (through supply chain articulators)
- Tactical planning for planting constrained by resources and stochasticity
- Incorporation of weather-based yield predictions into planning models
- Planning modeling for harvesting and distribution
- **First-mile planning for local and distant markets**
- **Evaluate total landed costs and environmental footprint**
- **Real time reconfiguration of supply chain (sensor-based)**

Research Areas

Market intelligence

Planning tools

System level design

- Data acquisition
- Data storage
- High level design of TERRa-Fresh
  - Elements
  - Tools to be deployed
  - Interaction between tools
  - Interaction between elements
- **User Interface**
- **Access and protection of information**
- **Real-time, sensor Interface**

Next steps

1. Verification of models
2. Validation of results (i.e., representative farms)
3. Pilot implementation
4. Dissemination of results
5. Finding partners for further development of the system

AGENDA

- Introduction of event
- Event Schedule
- Background
- TERRa Fresh Introduction and Demo
- Other Activities
- **Conclusions and Introduction to workshops**

Conclusions

- TERRa Fresh's objective is to take advantage of the new technological realities for:
  - Increasing income for small growers
  - Attracting new growers into the field
  - Providing the tools for collaboration among growers to capture opportunities previously unavailable
  - Providing tools for making possible the transformation of the supply chains of fresh produce
  - Eliminating waste and harmful emissions
  - Providing transparency to the industry
  - Providing traceability and other relevant information to the consumer to affect supply chain practices

FFAR Team

ASU Team

J. Rene Villalobos
George Runger
Arnie Maltz
Pat Phelan
Rodrigo Ulloa
Xaimarie Hernández Cruz
Grace Neal

Former ILPIL members

Hector Flores
Omar Ahumada
Octavio Sanchez

NMSU Team

Paul Gutierrez
Madhav Regmi
Chadelle Robinson

Other Partners

Jim Kallof
Patty Emmert
Paul Cordero
Duncan Family Farms
La Montañita Coop
Sol y Tierra Growers

ILPIL
International Logistics & Productivity Improvement Lab

FFAR

ASU Arizona State University

NM STATE UNIVERSITY

Mini-Container Team

Faculty:

J. Rene Villalobos

Pat Phelan

Students:

Keshawa Bandara

Levi Siwek

Derall Riley

Mahmmoud Syam

Sergio Lopez

Next Activities

9:50 – 10:45 AM Workshop on planning and coordination tools for fresh fruits and vegetables.
Facilitated by Paul Gutierrez and Omar Ahumada
Zoom Link: https://asu.zoom.us/j/89438758955

9:50 – 10:45 AM Workshop on Market Intelligence.
Facilitated by George Runger and Hector Flores
Zoom Link: https://asu.zoom.us/j/84135179486

9:50 – 10:45 AM Workshop on Cold Chain issues and mini-containers.
Facilitated by Pat Phelan and Jim Kallof
Zoom Link: https://asu.zoom.us/j/83865883671

11:00 – 11:30 AM Conclusions of Workshop.
Zoom Link: https://asu.zoom.us/j/82809504308

Links to workshops can be accessed at: http://terra-fresh.com/Events

THANK YOU

J. Rene Villalobos

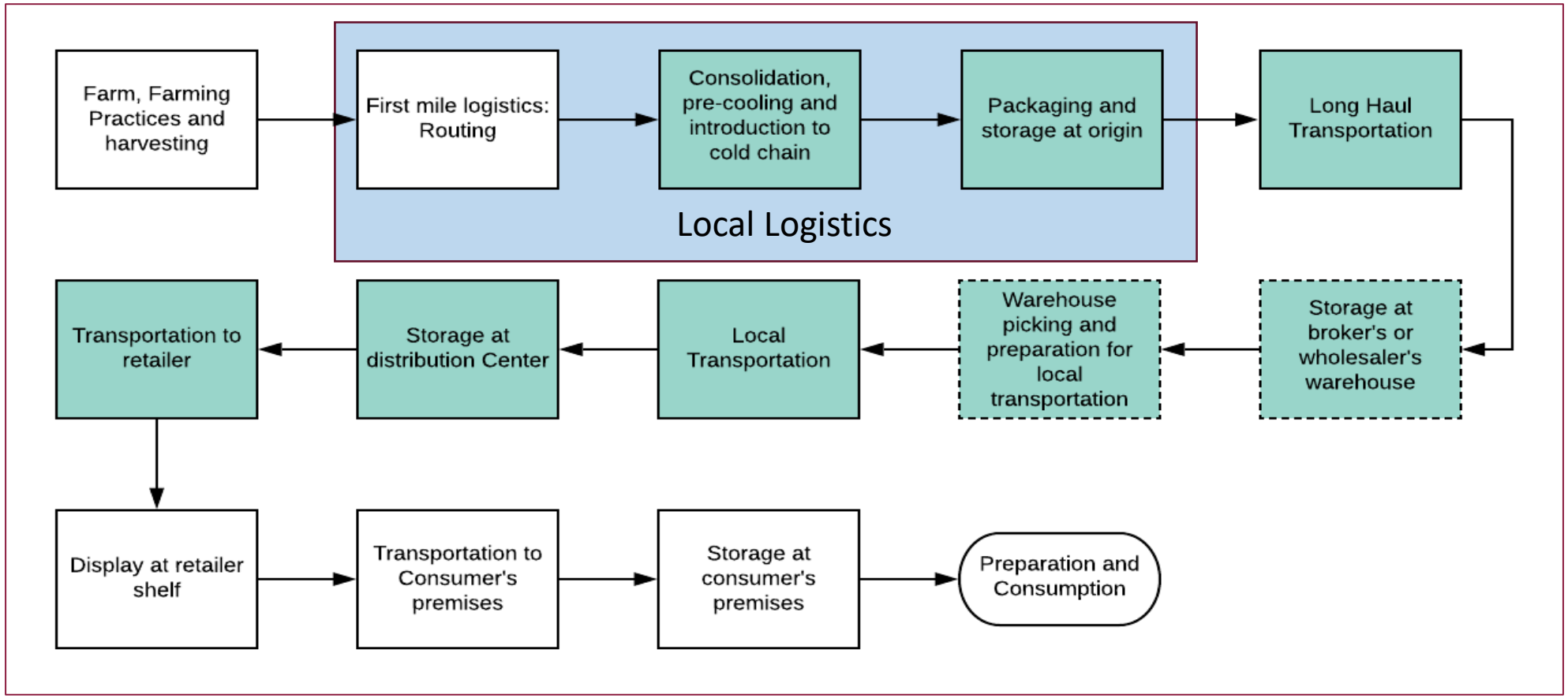
 rene.villalobos@asu.edu

International Logistics and Productivity Improvement Laboratory

 ilpil.asu.edu

School of Computing, Informatics and Decision Systems Engineering

Schematic of Current Fresh Produce Supply Chain

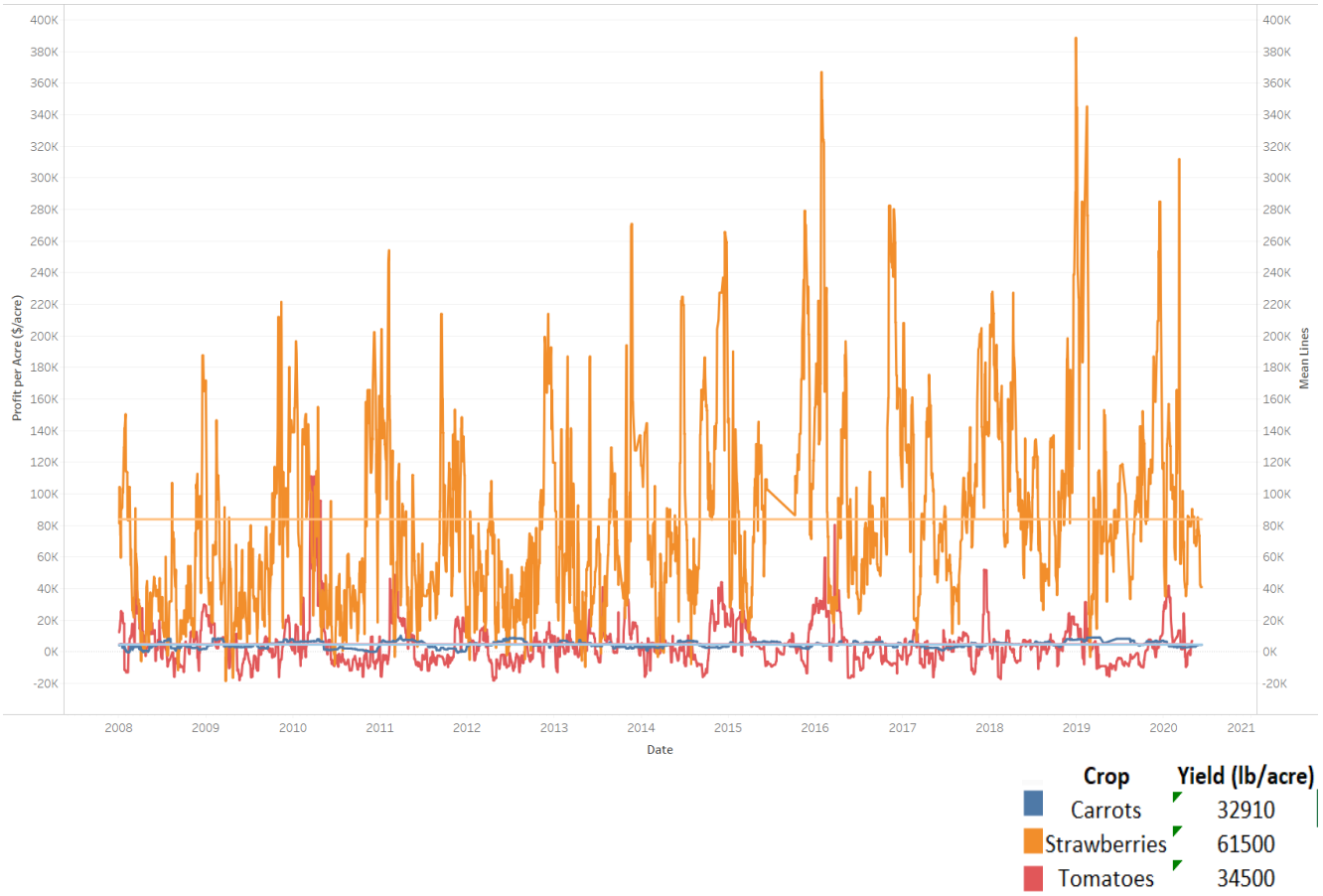


Integrated Planning Tool

- Considers **prices prediction** obtained through **Market Intelligence** tools.
- Considers **expected yields** for different regions generated from the **Agronomic Potential** module.
- Considers general regional **logistics parameters** and **costs**.
- Provides a recommended **production plan** for different type of users.
- Identifies the **best set of regions** to supply produce for an identified market signal, demand or opportunity.

Example of a Current Opportunity
(We know what we can know)

- Profit time series for crops with different shelf lives.
- It is expected that crops with higher shelf life will result in lower profits than crops with short shelf life.
- Revenue based on USDA terminal market prices.
- Costs based on production crop budgets and transportation costs.



Phases of Decision Support Tools Development

1. Initial platform for market and logistics data
2. Open access agronomic-potential module
3. Open access planting and planning module
4. Initial market intelligence and analytics module
5. Initial market negotiation platform
6. Develop general design of the demand side platform
7. Prototype of integrated platform

Some Benefits of the Mini-Containers

- Allows the aggregation of storage/transportation-incompatible small harvests into a single truck.
- Allows the virtual creation of cold storage facilities in places with limited access to these facilities.
- Allows the immediate introduction to the cold chain of harvests by having a CDU at the farmer's premises to do the precooling of crops.
- Allows the reduction of carbon footprint.
- Enables direct small farm-to-market transaction, skipping intermediaries and inefficient extra handling of the crops.
- Allows precise temperature and environmental control as well as full traceability and real-time tracking.
- Ideal for the upcoming automated and autonomous logistics systems.