S.C.C. SHARING: Satisfying Households in Areas with Food Insecurity with a Network for Good

PIs: [1]Julie S. Ivy, [1]Leila Hajibabai, [2]Lauren Davis, [3]Irem Sengul Orgut, [1]Munindar Singh,

Senior Personnel: [2]Steven Jiang, [2]Faisal Alkaabneh, [3]Emmett Lodree, [2]Shona Morgan, [3]Matthew Hudnall, [3]Dwight Lewis , [1]Ali Hajbabaie

[1]North Carolina State University; [2]North Carolina A&T State University, [3]University of Alabama

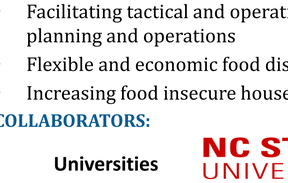
Hunger in the US

Pre-COVID (2020):
US average Food Insecurity 10.5%
35 Million food insecure individuals

Post-COVID (2020):
US average Food Insecurity 12.8%
42 Million food insecure individuals

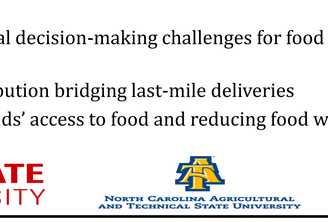
FOOD INSECURITY:

- Deviations in food insecurity level by location (NC 13.5%, AL 16.1%)
- 30-40% of the entire food supply is wasted
- COVID has increased food insecurity



Feeding America. (2019) https://map.feedingamerica.org/

FOOD RESCUE: The practice of collecting high-quality food that would otherwise go to waste and distributing it to people facing hunger.



Hunger Relief Operation (Feeding America)

Food Rescue Operation

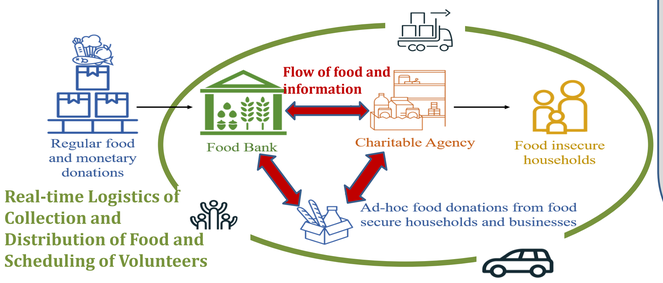
NSF SCC: SHARING

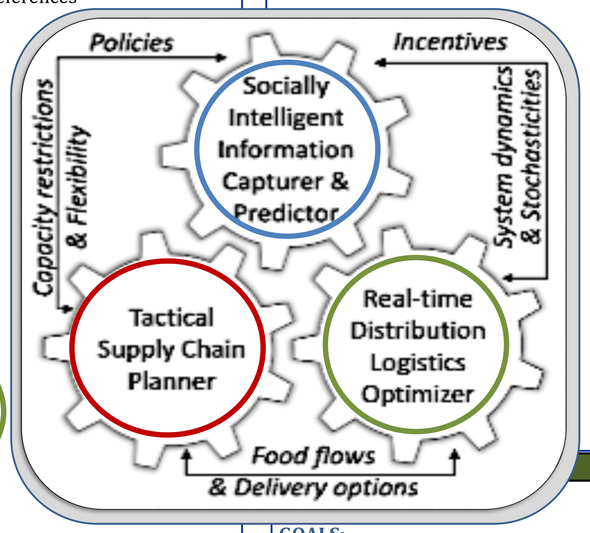
PROJECT GOAL:
To reduce the hunger gap by minimizing food waste along different stages of the supply chain while maximizing equitable access to safe food given food insecure household preferences

AIMS:

1. Understand the tendencies of donors, neighbors and volunteers by creating a socially intelligent infrastructure
2. To design and optimize the food sharing network in response to stakeholder behaviors by a data driven supply chain framework.
3. To satisfy beneficiary needs by communal self-renewal by connecting food insecure households to community-based supply options in real time, and optimizing real time logistics operations

PROJECT INFRASTRUCTURE:





ANTICIPATED IMPACT:

- Facilitating tactical and operational decision-making challenges for food banking and food rescue planning and operations
- Flexible and economic food distribution bridging last-mile deliveries
- Increasing food insecure households' access to food and reducing food wastage

COLLABORATORS:

Universities: NC STATE UNIVERSITY; North Carolina Agricultural and Technical State University; The University of Alabama

Food Banks: foodbank of Central & Eastern North Carolina; Second Harvest Food Bank of northwest nc; West Alabama Food Bank

Agencies: Root Causes; Shelton State Community College; Aggie Source Food Pantry; Out of the Garden Project; Feed the Pack, The Food Pantry at NC State; ACFS Alabama Childhood Food Solutions

Aim 1: Socially Intelligent Information Capturer and Predictor

GOALS:

1. Develop a community-scale socially intelligent infrastructure that adapts to consumer preferences and provides system actors transparency into network operations
2. Build a prosocial smart-sourcing mechanism to shape actor behaviors to benefit the network

METHODS: Monte Carlo simulation combining demand-side management (DSM) models, Interviews, Surveys, Field Observations, Value Stream Mapping

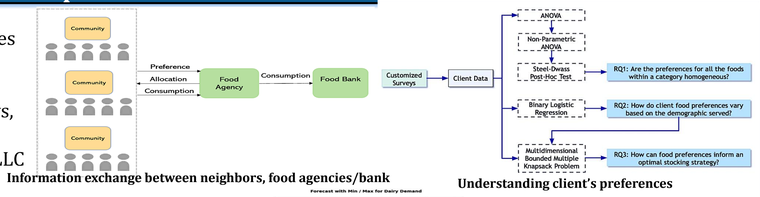
DATA: Neighbors report their preferences through surveys, One Step Further, Inc., and One Health, LLC

MAJOR ACHIEVEMENTS:

1. Created and used a survey to collect client needs and food preferences
2. Developed a preliminary DSM model for forecasting food demand and food cost using simulated data

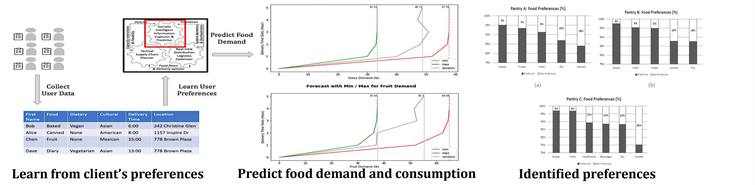
INSIGHTS ON MAJOR FINDINGS: There are two critical factors in developing an intelligent DSM model:

- (Understand clients) Collect accurate clients' preferences
- (Deliver value) Resolve discrepancies between actual and reported preferences and agency constraints



Information exchange between neighbors, food agencies/bank

Understanding client's preferences



Learn from client's preferences

Predict food demand and consumption

Identified preferences

Aim 2: Tactical Supply Chain Planner

GOALS:

1. Agent-based decision support to coordinate food bank and rescue operations
2. Manage the flow of in-kind and monetary donations and volunteer resources.
3. Optimize communitywide communication infrastructure and information sharing to inform timely donation collection and distribution.
4. Make strategies to enable a food bank community better prepare and respond to hunger needs under long-term disruptions

METHODS: Mixed Integer Linear Programming model

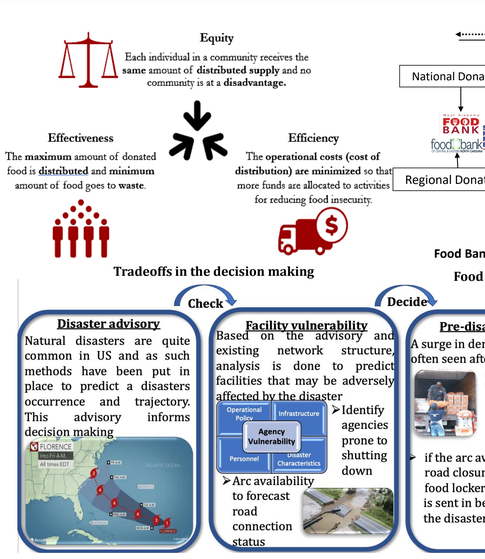
DATA: Partner Food bank

MAJOR ACHIEVEMENTS:

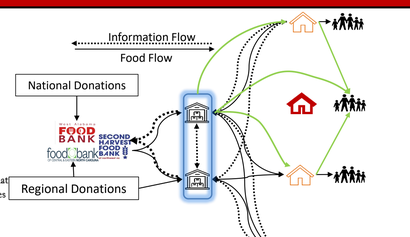
1. Formulated a multi-echelon food collection and delivery model among donors, food bank and charitable agencies incorporating storage and rescue capacities.
2. Identifying strategies for food and information flow during network disruption

INSIGHTS ON MAJOR FINDINGS:

- Multi-dimensionality of Food Insecurity
- Decentralized food rescue problem can be reduced to continuous knapsack problem and solved efficiently.



Tradeoffs in the decision making



Food and Information flow network

Aim 3: Real-time Distribution Logistics Optimizer

GOALS:

1. Develop a demand-responsive shared mobility system with various transportation modes
2. Schedule deliveries at consumer locations or corresponding neighborhoods given food safety time-windows

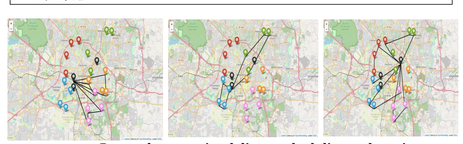
METHODS: Branch and Price, Lagrange Relaxation, Clustering and Routing

MAJOR ACHIEVEMENTS:

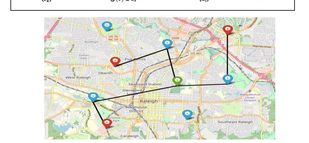
1. Allocate and route volunteers to food agencies considering equity and efficiency
2. Allocate and route volunteers to take food from the agencies to the food insecure households

INSIGHTS ON MAJOR FINDINGS:

- Identified empirical relationship between equity and efficiency in assigning volunteers to locations
- Depending on food bank's perception of equity, volunteers are chosen to be assigned to locations



Demand-responsive delivery scheduling and routing optimization for food agency volunteers(Study 1)



Volunteer Assignment and Route Design(Study 2)

NEXT STEPS

1. Prototype app for enabling actor interactions and collecting requisite data
2. Accommodate donor and volunteer behaviors in predictive models
3. Develop models for food and information flow and building a resilient supply chain
4. Make models and decision support tool for a demand-responsive logistics system

Broader Impacts

1. Connecting food rescue organizations to share resources and best practices
2. Contributing to the creation of a college food pantry
3. Incorporating diverse definitions of equity that align with objectives of partners
4. Make food more accessible to populations having mobility challenges