Scalable

Sustainable

affordable

Breakthrough technologies to

Remake farming for modern cities

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LBNL in partnership with ITT

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LAWRENCE BERKELEY NATIONAL LABORATORY

Institute for Globally Transformative Technologies
at the Lawrence Berkeley National Lab

"Bringing Science Solutions to the World"

- 3,500 scientists & engineers
- $800 million of annual R&D
- 13 Nobel Laureates
- Historically US-focused

"Bringing Science Solutions to the Developing World"

- Leverage LBNL's unparalleled technology capabilities
- Rigorous 'real-world' product engineering
- Powerful partnerships with influential institutions and businesses around the world
- Innovative business models and funding mechanisms

Water

- In the US irrigation accounts for 37% of freshwater withdrawals.
- In a state like CA agriculture accounts for 80% of water use.
- Intensive irrigation can waste as much as 40 percent of the water withdrawn.
- 44% of US streams and waterways are estimated to be impaired with agriculture the largest contributor

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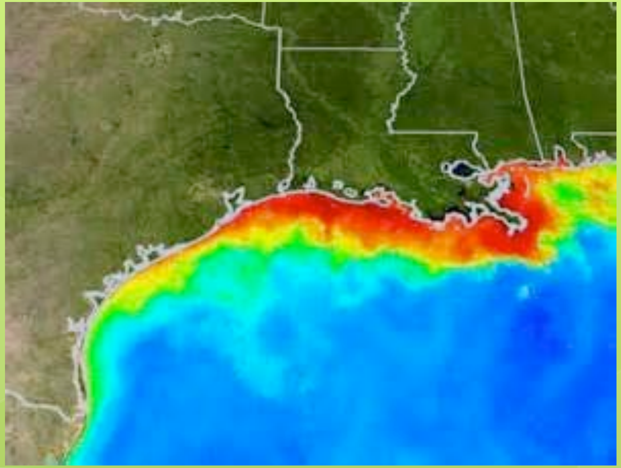
Fertilizer

- In the US we use of 60 million tons of fertilizer each year.
- Excess fertilizer pollutes streams and water ways and leads to algal blooms and dead zones in the Great Lakes and oceans



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Pesticides

- In the US we use of 1 billion pounds of pesticides each year, with a cost of over $12B dollars.
- 95 to 98% of pesticides reach a destination other than their target species.
- Pesticide use is associated with health problems for both consumers and farm workers as well as environmental damage

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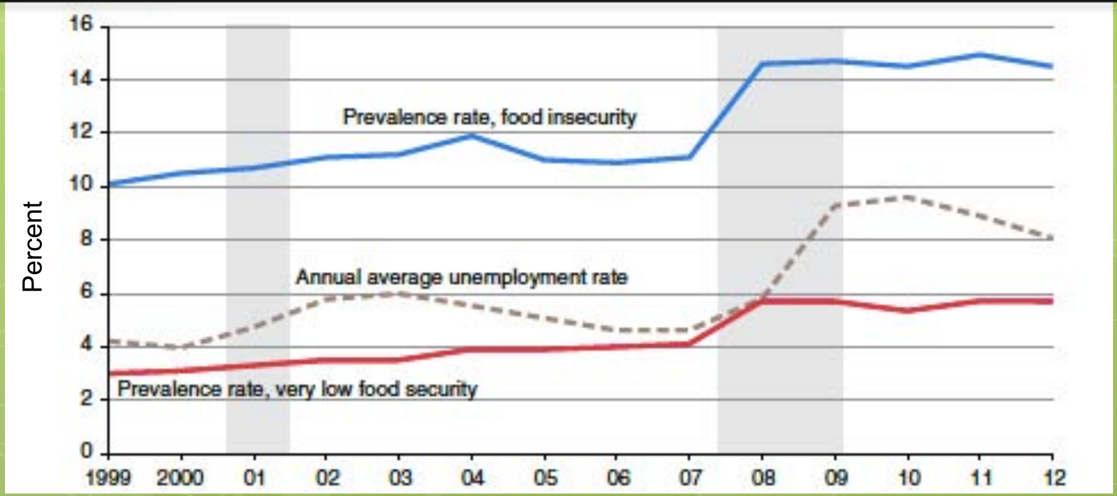
Food insecurity in America: Core statistics

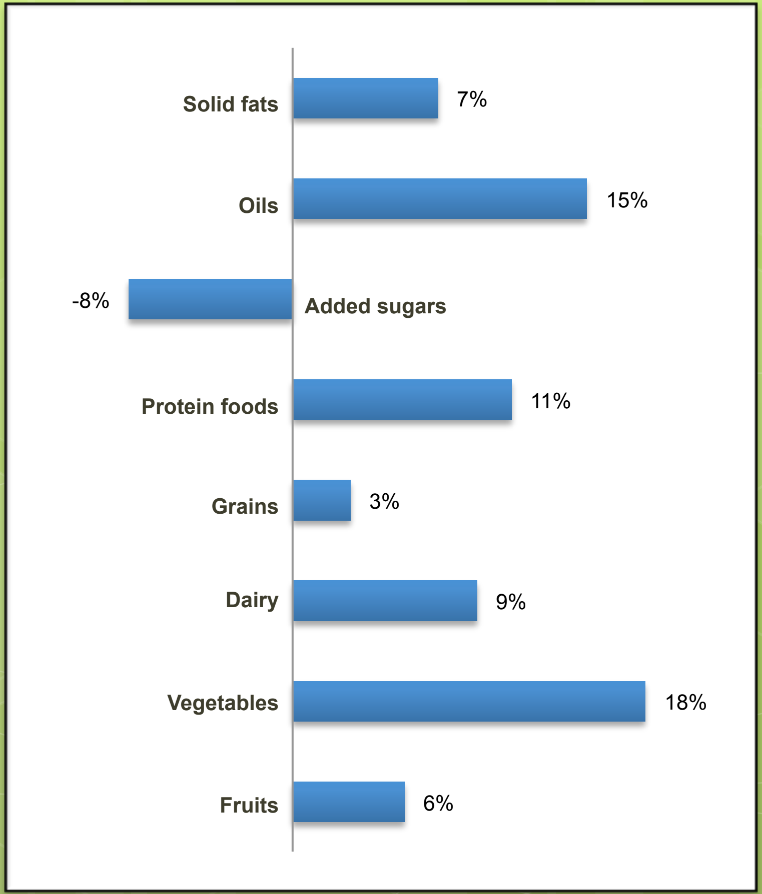
USDA Definitions		
	Low food security (*aka* Food insecurity without hunger)	• Reports of reduced quality, variety, or desirability of diet • Little or no indication of reduced food intake
	Very low food security (*aka* Food insecurity with hunger)	• Reports of multiple indications of disrupted eating patterns and reduced food intake

Prevalence of food insecurity and very low food security vs. national unemployment rate (1999-2012)



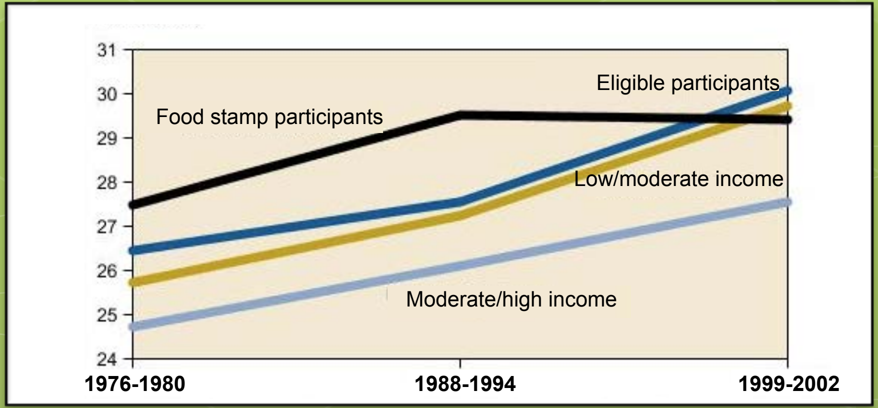
Food insecurity in America: Consumption patterns

Food consumption gap, higher vs. lower income population

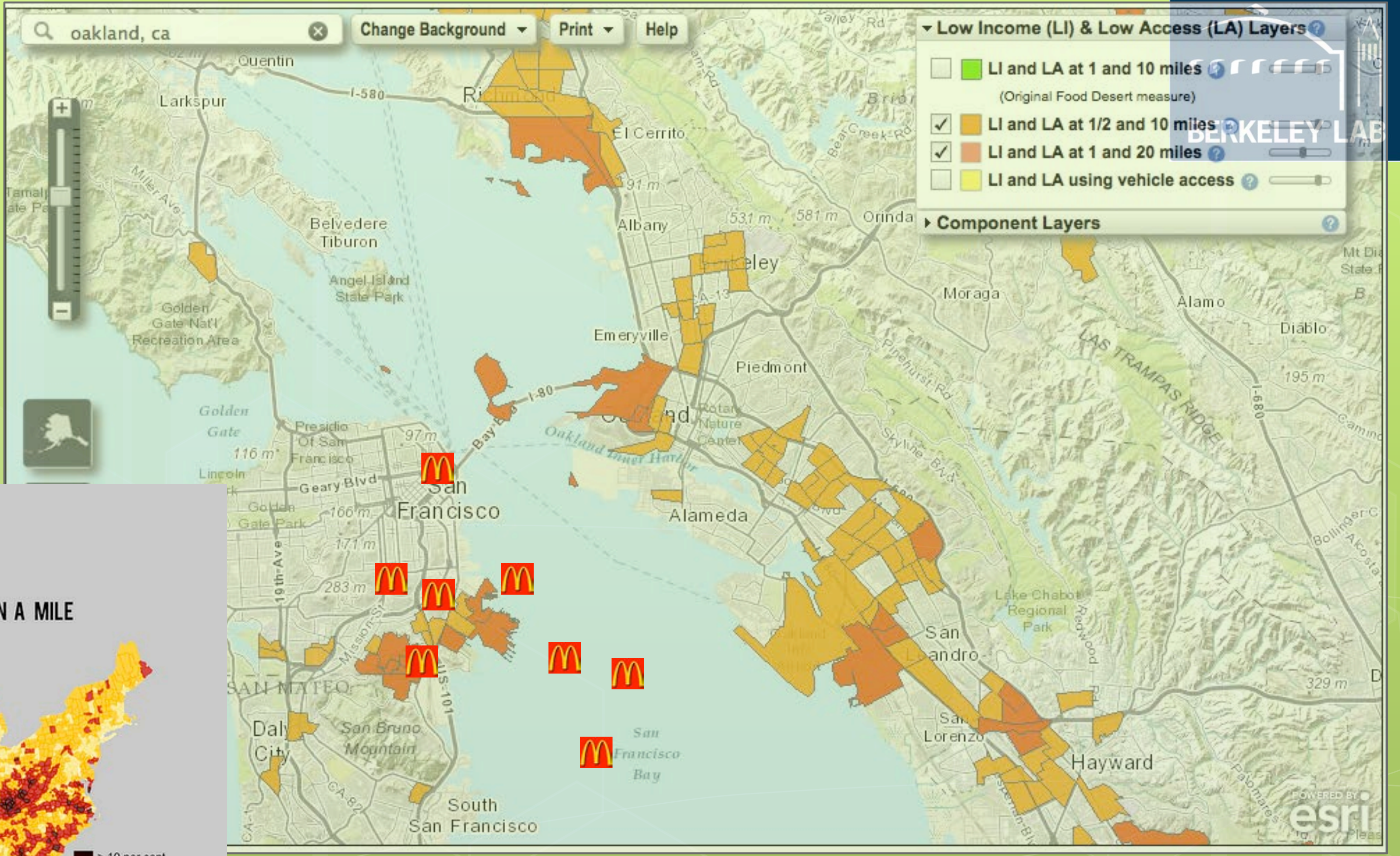


Percent of population that is obese, by income group

Convergence of obesity across income groups, BMI



Food desert map in Oakland



Feeding Oakland Lettuce

- Annual consumption 9,709,447 lbs.
- 151.6 Million gallons of water
- 20.6 tons of fertilizer
- 229 lbs. of pesticide
- 16,827 gallons of diesel fuel to transport
- 167.5 tons of CO_2 to transport

What would it take to grow nutritious food...

Locally?
Sustainably?
Cost effectively?

Precision Urban Agriculture

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Targeted use of resources

- Sharply limiting use of water, nutrients, and space
- No pesticides, herbicides and insecticides

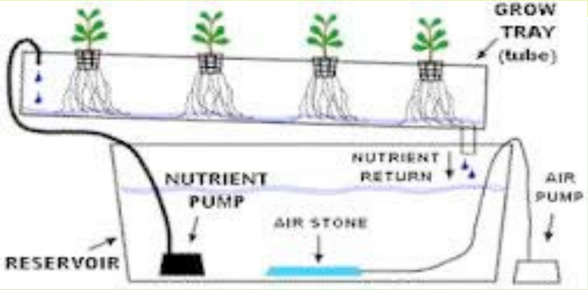
Environmental Controls

- Lighting
- Heating and cooling
- Air flow

Efficiencies in the production to consumer chain

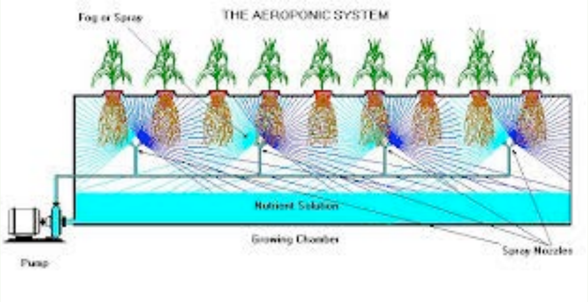
- Reduce waste in transportation and marketing
- On demand harvest
- Year round growing
- Efficient integration with urban scale users

New Growing Techniques



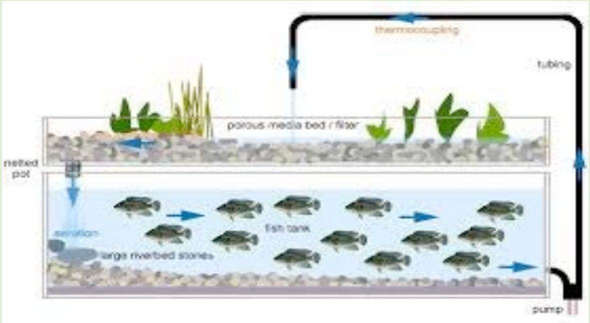
Hydroponics

- Plant roots grow in water
- 5-10% of the water
- No pesticides



Aeroponics

- Plant roots grow in air
- Nutrient and water mist
- 3-10% of the water
- No pesticides
- Faster growth cycles



Aquaponics

- Plants and food fish grown in a symbiotic biosystem
- 10-30% of the water
- No pesticides
- No fertilizer

Local Roots Farms,
Los Angeles, CA

- 320 Sq/ft shipping containers produce up to 5,000 lbs leafy greens/month
- 1 container ~ 1 job
- No pesticides, insecticides, or herbicides
- 5% water usage of traditional agriculture
- Co-locate with customers to eliminate supply chain waste
- Just-in-time crop production

Innovation in Action

Aerofarms,
Newark, NJ

- 69,000 Sq/foot former factory
- Will produce 1.5M pounds of produce a year
- 5% of water use to traditional agriculture
- 70 jobs
- Enough produce to supply 60,000 people

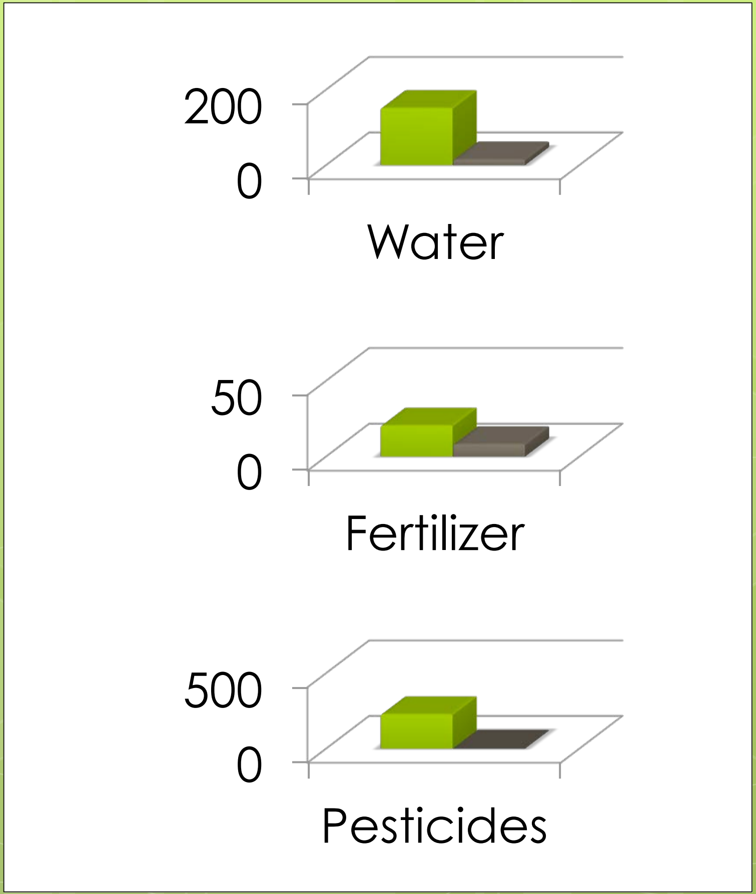
Innovation in Action

Gotham Greens,

Brooklyn, NY

- Hydroponic growing
- 15,000 Sq/foot rooftop greenhouse
- Produces 200,000 lbs of greens per year
- No pesticides, insecticides, or herbicides
- 5% of water use
- All electrical needs supplied by solar
- Gets heat and provides insulation to building below

Feeding Oakland Lettuce

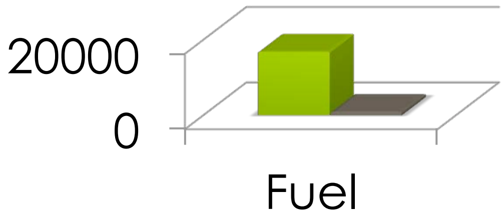


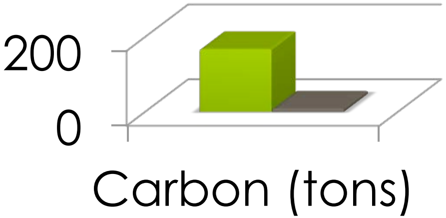
Savings = 136.44 Million Gallons

Savings = 12.36 Tons

Savings = 229 pounds

Feeding Oakland Lettuce





Savings = 15,986 Gallons

Savings = 159 Tons

What are the issues

- Cost competitiveness with traditional agriculture
- Ability to operate at scale
- Optimizing growing efficacy in a non-traditional environment

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Four Stage Study

Life Cycle Analysis

- Understand full costs
- Identify opportunities for efficiencies

Plant Growth Analysis

- Compare nutrient profiles to traditional agriculture
- Explore strategies to enhance nutrient profile & plant growth

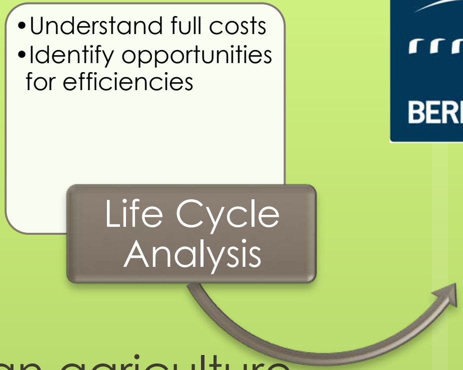
Tech Solutions

- Harness breakthrough technologies to support precision agriculture

City Pilots

- 3 Urban pilots
- Identify policy synergies
- Produce at scale

Life Cycle Analysis



- Questions to be answered
  - What are the full costs of existing precision urban agriculture efforts and how do they compare to conventional agriculture
  - Given the current costs what are the opportunities for efficiency
  - What are the monetized environmental and other benefits—and how do they compare to conventional agriculture
- Study
  - Analyze figures from existing efficient growers

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Understanding the state of the field

1. Critical review of existing scientific and technical literature

- Understand base-line conditions: cost and environmental footprint of conventional agriculture
- Status of existing and emerging technologies for precision urban agriculture
- Breakdown of main drivers of cost structure, energy use, resource use
- Identify and monetize indirect costs and impacts, e.g. pollution, erosion, water depletion

2. Collect and analyze operational data from existing urban growers

- Compile and compare original data on production rates, economy, energy, resources, etc.
- Breakdown of main drivers of cost structure, energy use, resource use
- Identify similarities and differences between growers, to discern success factors
- Determine best practices for urban farming in different geographic/ environmental conditions

Life Cycle Analysis

- Understand full costs
- Identify opportunities for efficiencies

Plant Growth Analysis

Plant Growth Analysis

- Compare nutrient profiles to traditional agriculture
- Explore strategies to enhance nutrient profile & plant growth

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- Questions to be answered
  - How do the nutrient and micro-nutrient profiles of plants grown without soil compare to those grown by traditional farming?
  - How do changes in lighting, nutrient delivery, seed coating, etc. impact plant growth, productive capacity and nutrient profile
- Study
  - Plant nutrient profiles based on samples from crops currently in production with existing growers
  - Use experimental units to collect data on how input changes impact plant growth and nutrient profile

- Harness breakthrough technologies to support precision agriculture

Tech Solutions

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Tech Solutions

- Questions to be answered
  - What are the specific technological solutions that can be used to decrease costs, increase productivity, enhance nutritional value, or reduce environmental footprint of precision urban agriculture efforts?
- Study
  - Build test units on lab campus that will support experimentation around key aspects of precision urban ag systems.
  - Partner with innovative growers to test technological solutions in real world applications.

Tech Solutions

Problem: Optimizing Lighting

- Harness breakthrough technologies to support precision agriculture

Tech Solutions

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Solution space:

- Increased efficiency in LEDs,
- lighting recipes (variations in wavelength, strobe, pulse and daylight cycles to optimize growth),
- fiber optics for daylight harvest,
- nanotechnology for self-cleaning and condensation run off in greenhouse glass.

Tech Solutions

Problem: Climate Control

- Harness breakthrough technologies to support precision agriculture

Tech Solutions

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Solution space:

- Reduced excess heat from lighting,
- symbiotic heating and cooling with surrounding buildings,
- high efficiency greenhouse materials,
- heat exchanges,
- enhance uniform airflow distributions

Tech Solutions

Problem: Optimizing nutrient uptake

- Harness breakthrough technologies to support precision agriculture

Tech Solutions

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Solution Space:

- Test how to support beneficial plant- microbe interaction in soilless growing
- Develop plant specific nutrients sustainably reducing energy footprint
- Identify soluble organic nutrients appropriate to hydro, aero and aquaponic growing
- Test seed coatings and other mechanisms to promote efficient uptake

Tech Solutions

Problem: Efficient use of water

- Harness breakthrough technologies to support precision agriculture

Tech Solutions

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Solution Space:

- Address issues with water recapture: Desalinization; nutrient rebalancing; sterilization; ion specific probes for water analysis
- Compare effectiveness of hydroponic and aeroponic technologies

City Pilots

City Pilots

- 3 Urban pilots
- Identify policy synergies
- Produce at scale

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- Questions to be answered:
  - What are the policy; procurement and institutional relationships which will:
    - Ensure impact on low income urban populations
    - Optimize other beneficial impacts of the urban landscape (jobs, reinvestment, etc)
    - Ensure business viability for growers
- Study
  - Pilot initiatives in three urban centers

City Pilots

- Defined benefits and commitments from each partner
- Pilots in three cities (West Coast, Midwest, East Coast)
- Integrate precision agriculture into urban policy environment
- Implementation design to ensure food produced impacts health in food deserts

City Pilots

- 3 Urban pilots
- Identify policy synergies
- Produce at scale

Commitments and benefits for urban partners

City Pilots

- 3 Urban pilots
- Identify policy synergies
- Produce at scale

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Commitments

- Help identifying and acquiring suitable space
- Shifts in zoning, regulations and tax policy to support urban farming
- Support negotiating electrical rates comparable to current farm rates
- Help build partnerships with key scale consumers reaching low income populations (schools, WIC, hospitals, etc.)
- Tie ins to other programs for the urban poor (jobs programs, efforts to impact healthy life styles, urban redevelopment, etc.)

Benefits

- Dedicated portion of production for partners and programs feeding the urban poor at an agreed upon price point.
- Job creation
- Secondary economic benefits to local economy
- Health impacts on urban communities

Commitments and benefits for growing partners

City Pilots

- 3 Urban pilots
- Identify policy synergies
- Produce at scale

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Commitments

- Dedicate portion of production for partners and programs feeding the urban poor at an agreed upon price point.
- Local hiring

Benefits

- Help identifying and acquiring suitable space
- Shifts in zoning, regulations and tax policy to support urban farming
- Support negotiating electrical rates comparable to current farm rates
- Access to key scale consumers reaching low income populations (schools, WIC, hospitals, etc.)

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