The Vertical Farm: Keystone Concept to the Sustainable Eco-city

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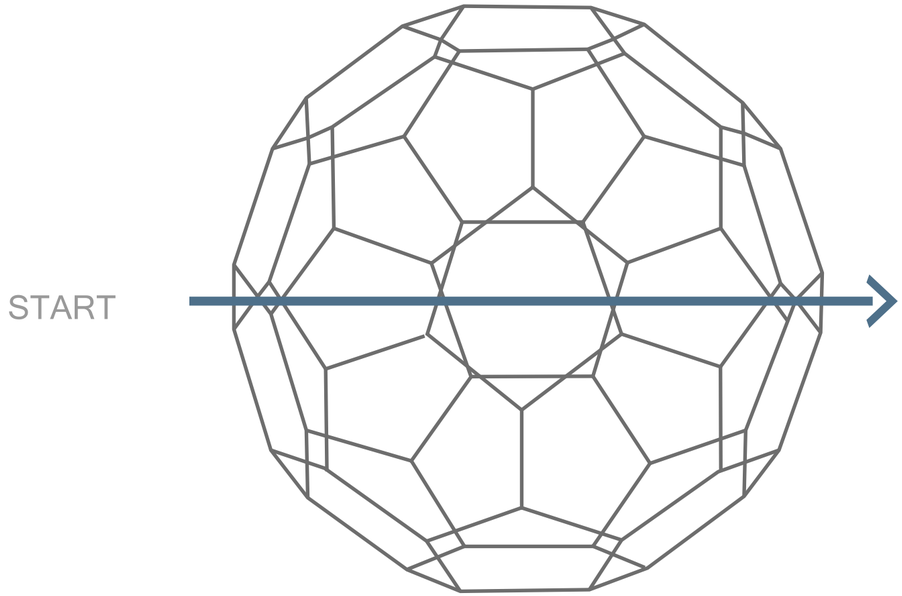
EMERITUS PROFESSOR OF
PUBLIC HEALTH,
COLUMBIA UNIVERSITY

Biosphere

NO BEGINNING, NO END

Techno-sphere



“Cradle to cradle”

“Cradle to grave”

Everyone’s Birthright:

2.3 Liters of safe drinking water

1500 Calories of safe food

The Challenges

- Safe and Abundant Water Supply
- Food Safety and Security
- Engaging Society in Environmental Sustainability
- Reducing Dependence on Fossil Fuels


6.8
Billion
People
Agricultural Footprint
Not including grazing lands

World Population Growth

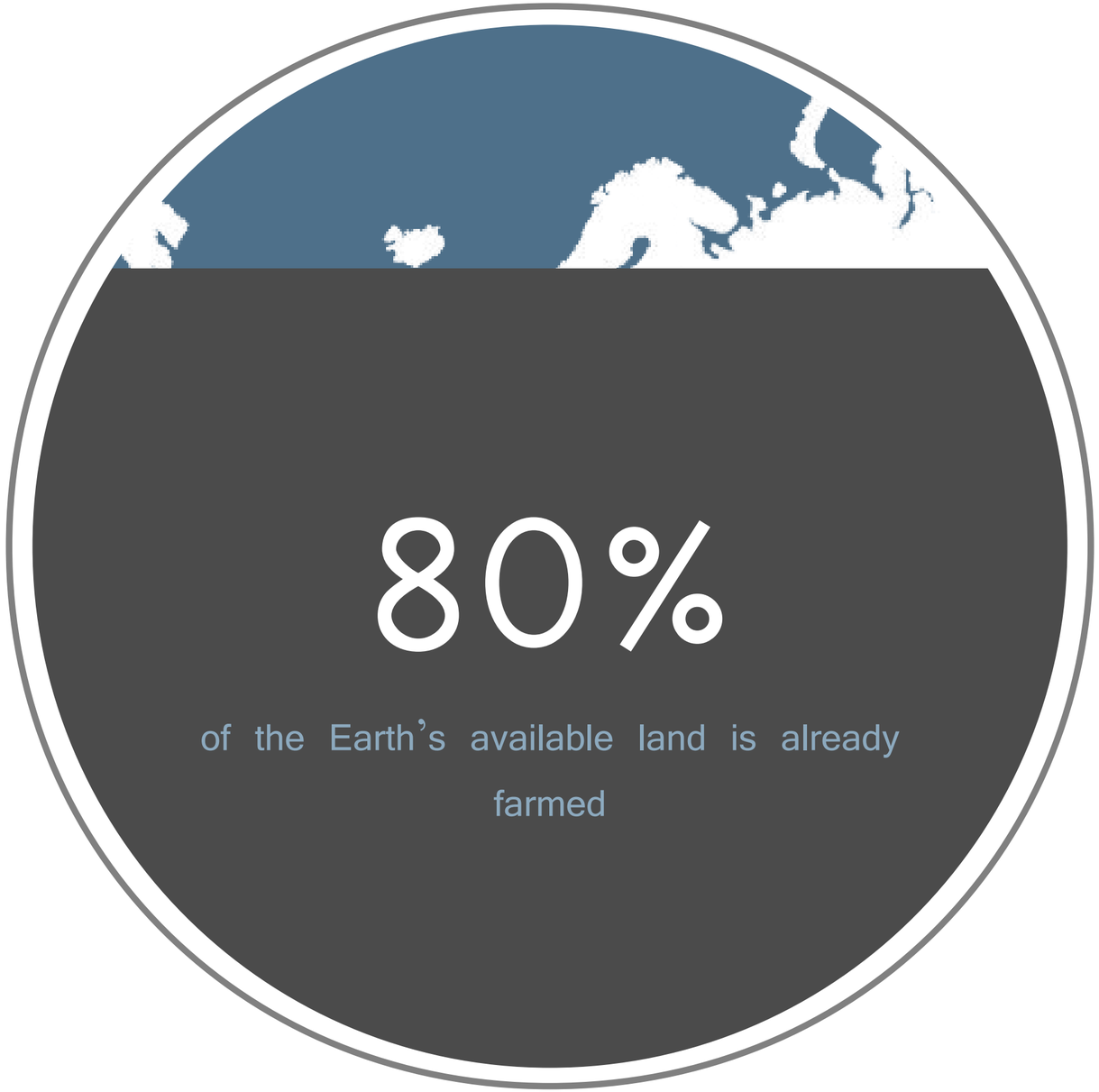
WORLD RESOURCES INSTITUTE

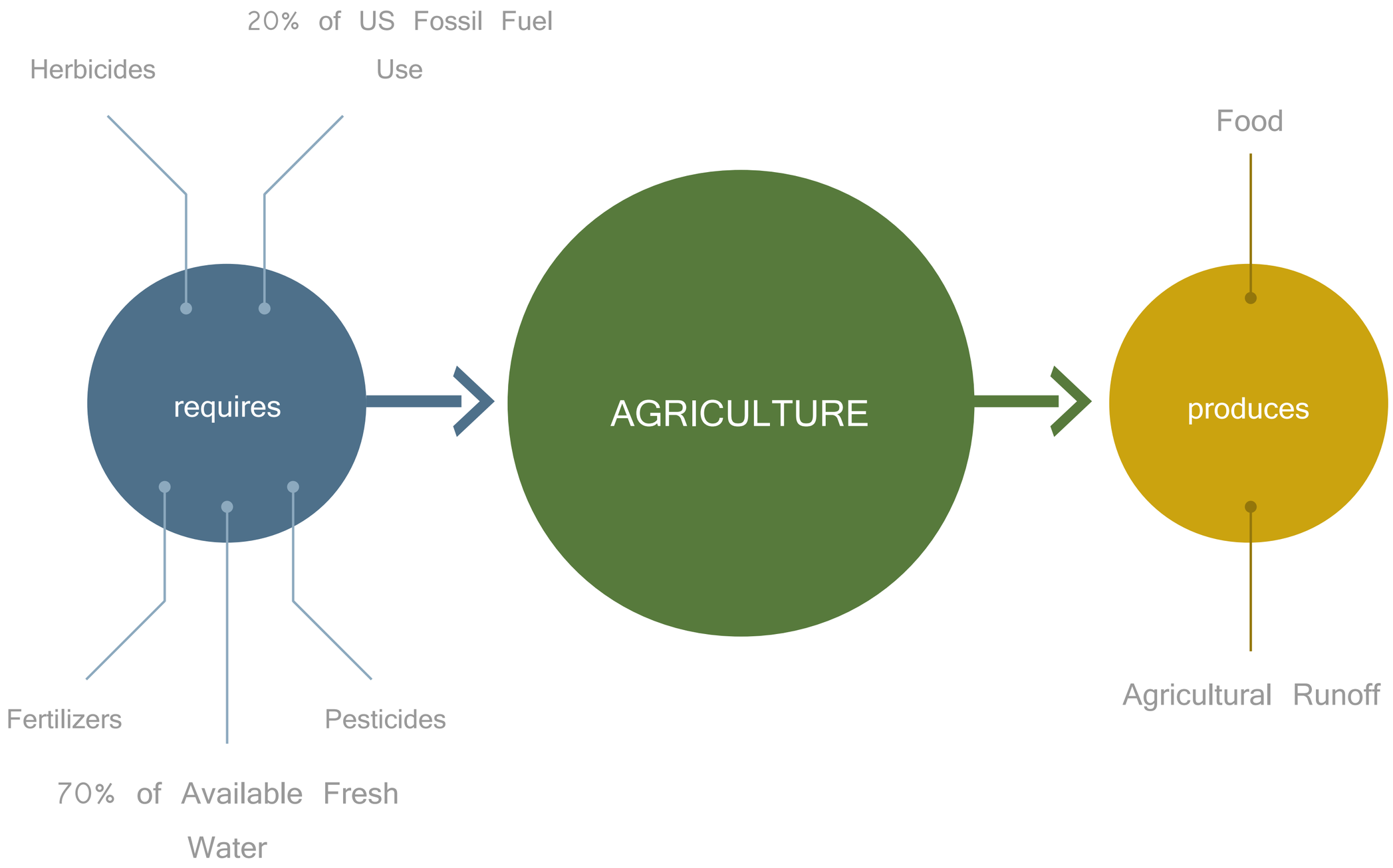
Sources: United Nations Population Division and Population References Bureau, 1993

Forecasting Agriculturally Driven Global Environmental Change

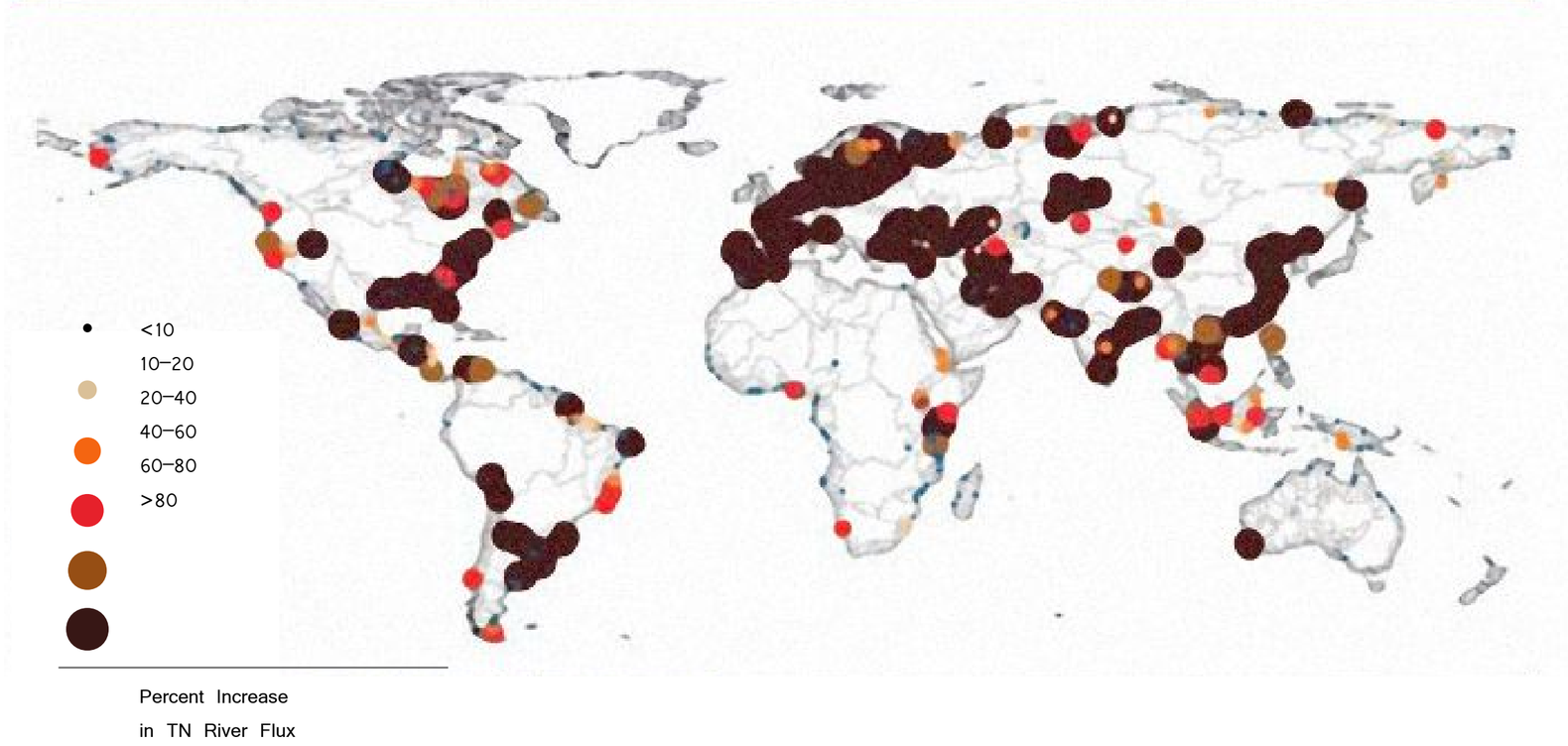
David Tilman, et al.

SCIENCE Vol 292—April, 2001

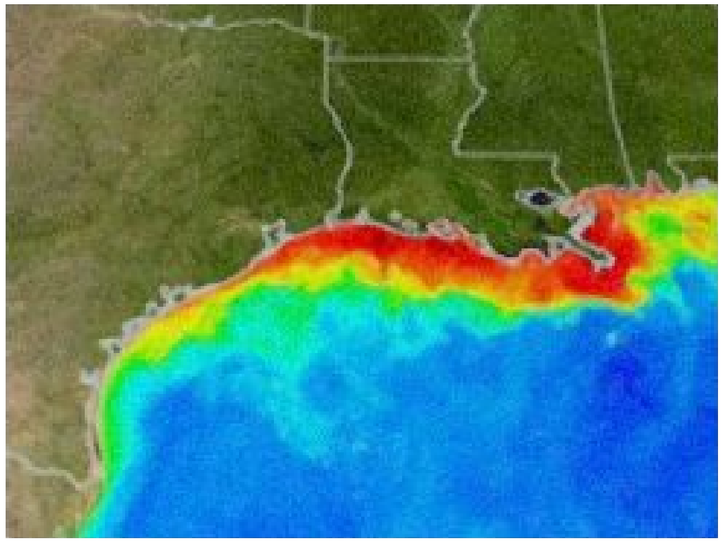

80%
of the Earth's available land is already farmed


20% of US Fossil Fuel Use
Herbicides
requires
AGRICULTURE
produces
Food
Agricultural Runoff
Fertilizers
Pesticides
70% of Available Fresh Water

Agricultural Runoff is Destroying the World's Oceans



Dead Zones



US Floods:
1993, 2007, 2008

Within 20 years, **80%** of us will live in cities or suburbs


Provide a sustainable, safe and abundant food and water supply for 10 billion people?
AND
Repair Earth's damaged ecosystems?

Can We?

We Can If we Want To

The Future of Agriculture: Growing Soilless

Hydroponics

Aeroponics

Drip Irrigation

The Future Is Now

Rice from Japan

Lettuce from Tennessee

Tomatoes

EuroFresh Farms, Willcox, Arizona

Endless Possibilities

Variety Is The Spice Of Life








Berries
Blackcurrant
Blueberry
Cranberry
Huckleberry
Loganberries
Raspberry
Strawberry

Bush Vegetables
Green Bean
Tomato-- beefsteak, campari, plum, cherry, globe

Specialty Crops
Coffee
Grapes
Luffa Sponge
Olives
Sunflower
Wheat Grass

Vine Vegetables
Cucumber
Eggplant
Okra
Squash
Sweet Bell Pepper
Zucchini

Legumes
Soybeans
Peanuts

Melons
Cantaloupe
Muskamelon
Pumpkin,
Watermelon

Root Vegetables
Beet
Belgian Endive
Carrot
Onions
Potato
Radish
Sweet Potato

Grains
Barley
Corn,
Wheat
Rice

Leafy Greens
Asparagus
Butterhead Lettuce
Broccoli Brussels Sprout
Cauliflower
Celery
Charita Lettuce
Chinese Cabbage
Collared Greens
Estelle Lettuce
Garlic Chives
Green Coral Lettuce,
Green Oak Leaf Lettuce,
Kale
Kuala Lettuce
Mizuna Mustard
Peas
Red Coral Lettuce
Red Oak Leaf Lettuce
Romaine Lettuce
Roxy Lettuce,
Spinach
Swiss Chard
Upland Cress

Herbs & Spices
Arugula
Banana Pepper
Bay Leaves
Chile Peppers
Chervil
Chives
Cilantro
Cinnamon Basil
Coriander
Curry Leaf Dill
Fennel
French Tarragon
Green Basil
Lavender
Lemon Basil
Lemon Thyme
Marjoram Mint
Opal Basil
Oregano
Parsley
Rocket
Rosemary
Sage Sakura Cress
Thai Basil
Watercress
Yellow Pea Shoots





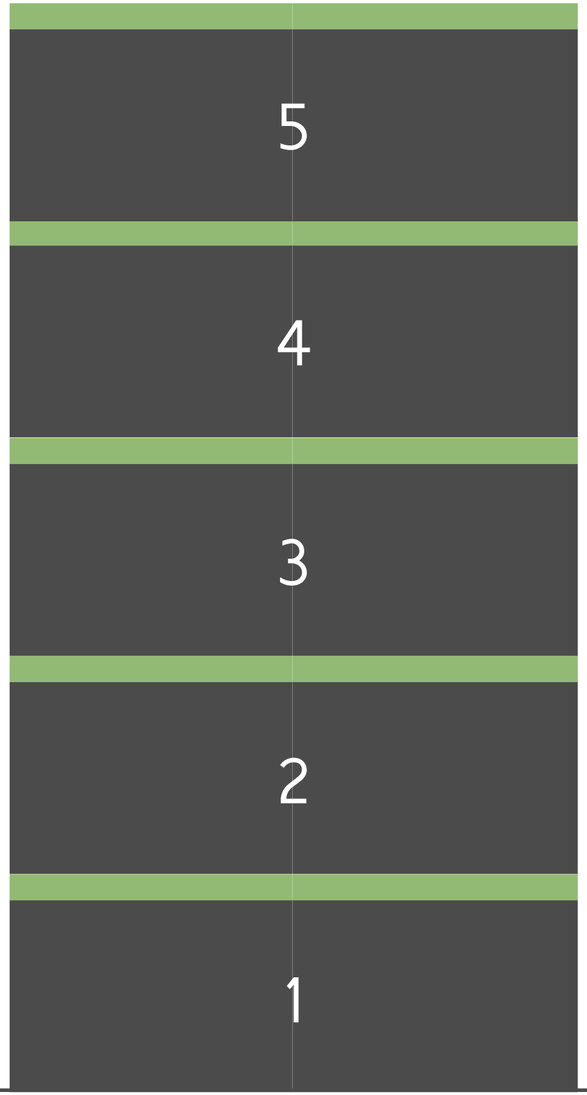



Apply these proven indoor agricultural strategies to growing food in buildings located within the urban landscape…

The Result:

Vertical Farming

Advantages of a Vertical Farm



ALLOWS RESTORATION OF DAMAGED ECOSYTEMS

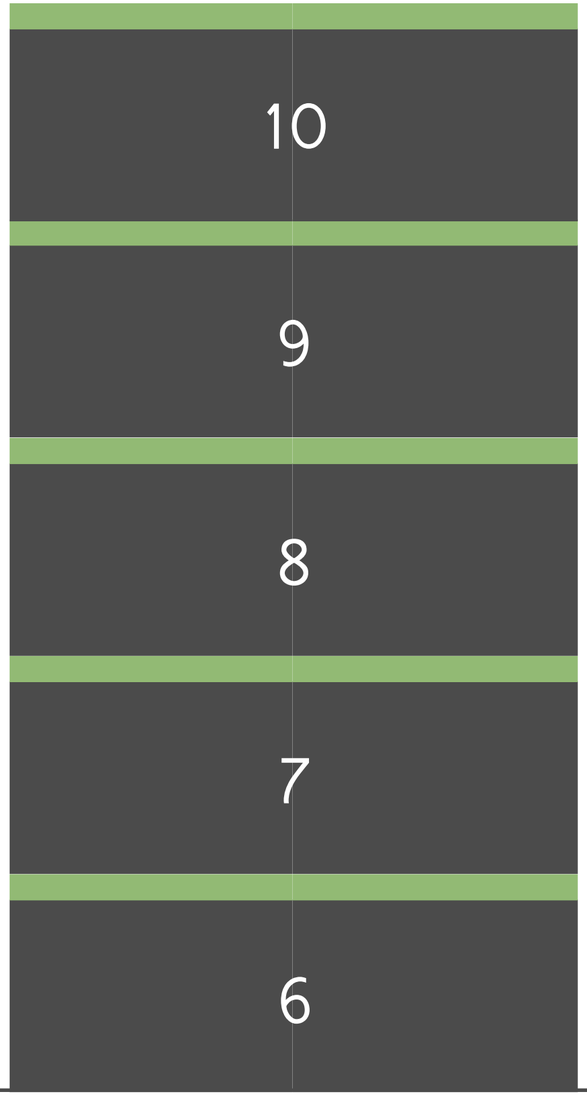
USES 70% LESS WATER, NO AGRO-CHEMICALS, NO FOSSIL FUELS

NO CROP LOSS FROM SEVERE WEATHER EVENTS

YEAR ROUND CROP PRODUCTION

NO AGRICULTURAL RUNOFF

Advantages of a Vertical Farm



CAN GROW BIO-FUELS, PLANT-DERIVED DRUGS

USES ABANDONED CITY PROPERTIES

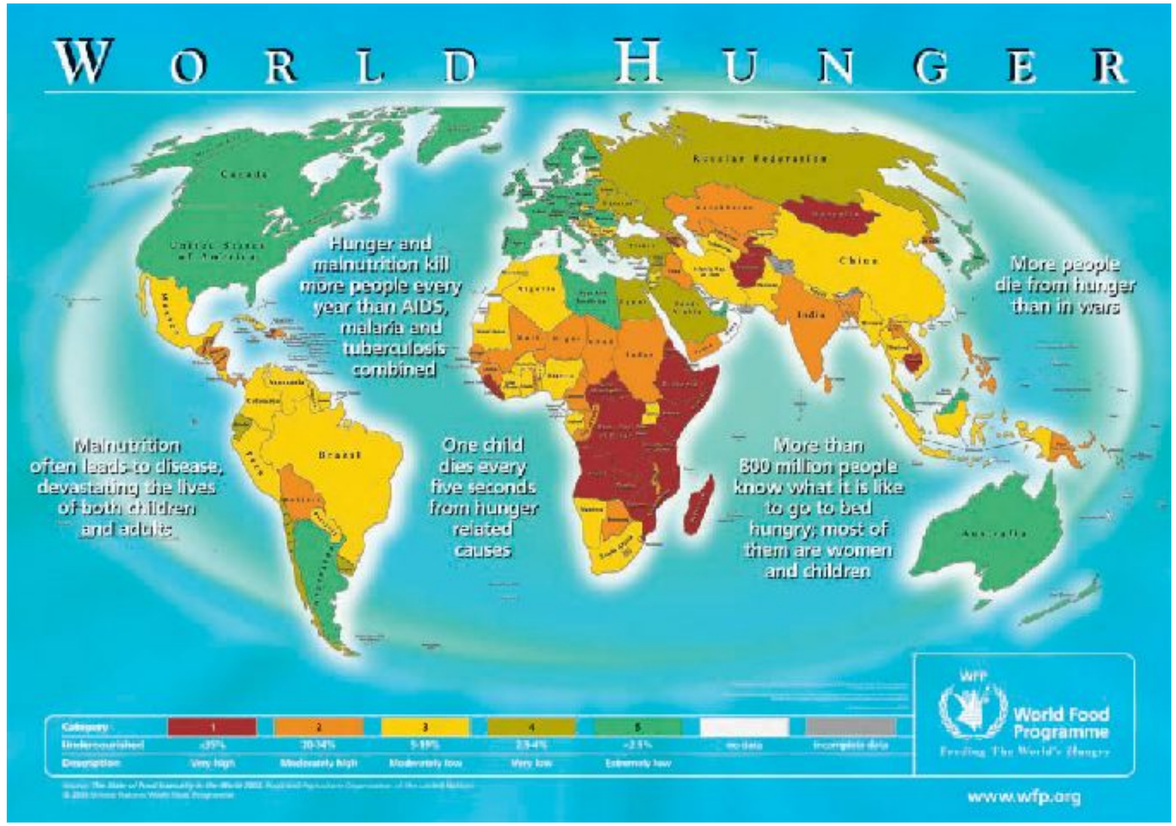
SUPPLIES FRESH PRODUCE FOR INNER CITY DWELLERS

CREATES NEW JOBS

REMEDIATES GRAY WATER

Addresses Two Urgent Needs in Distressed Regions of the World

Food



Water

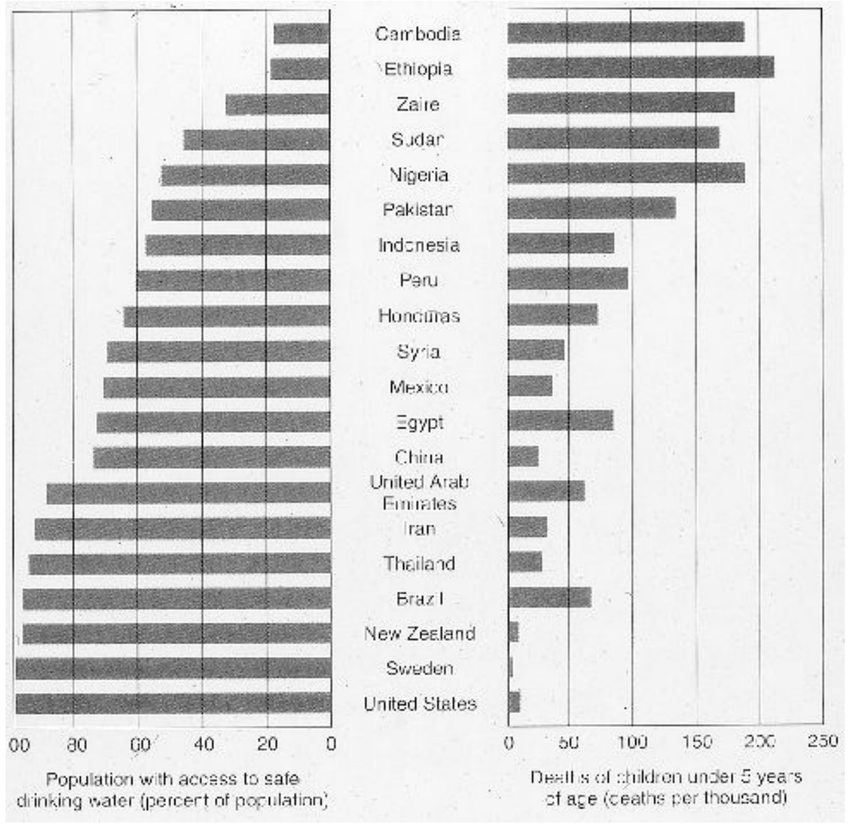
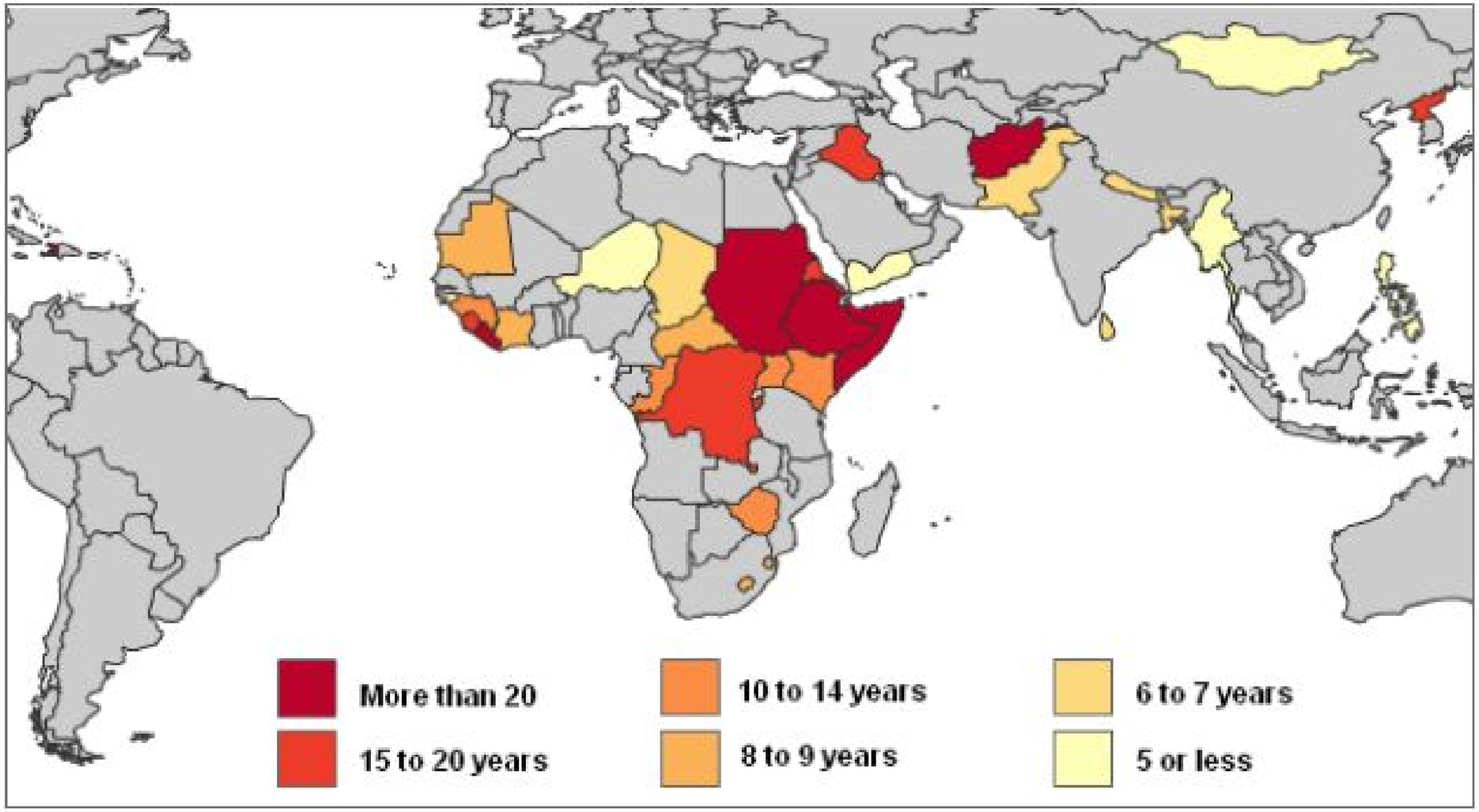


Figure 1: Location and duration of food emergencies



Source: based on GIEWS (2010).

The Vertical Farm: Key to Eco-Urbanization

The Vertical Farm is the centerpiece for creating an eco-city in which all human activities reflect ecological process.

Vertical Farm Tool Box

Hydroponics

Aeroponics

Drip Irrigation

Waste-to-Energy

Automation

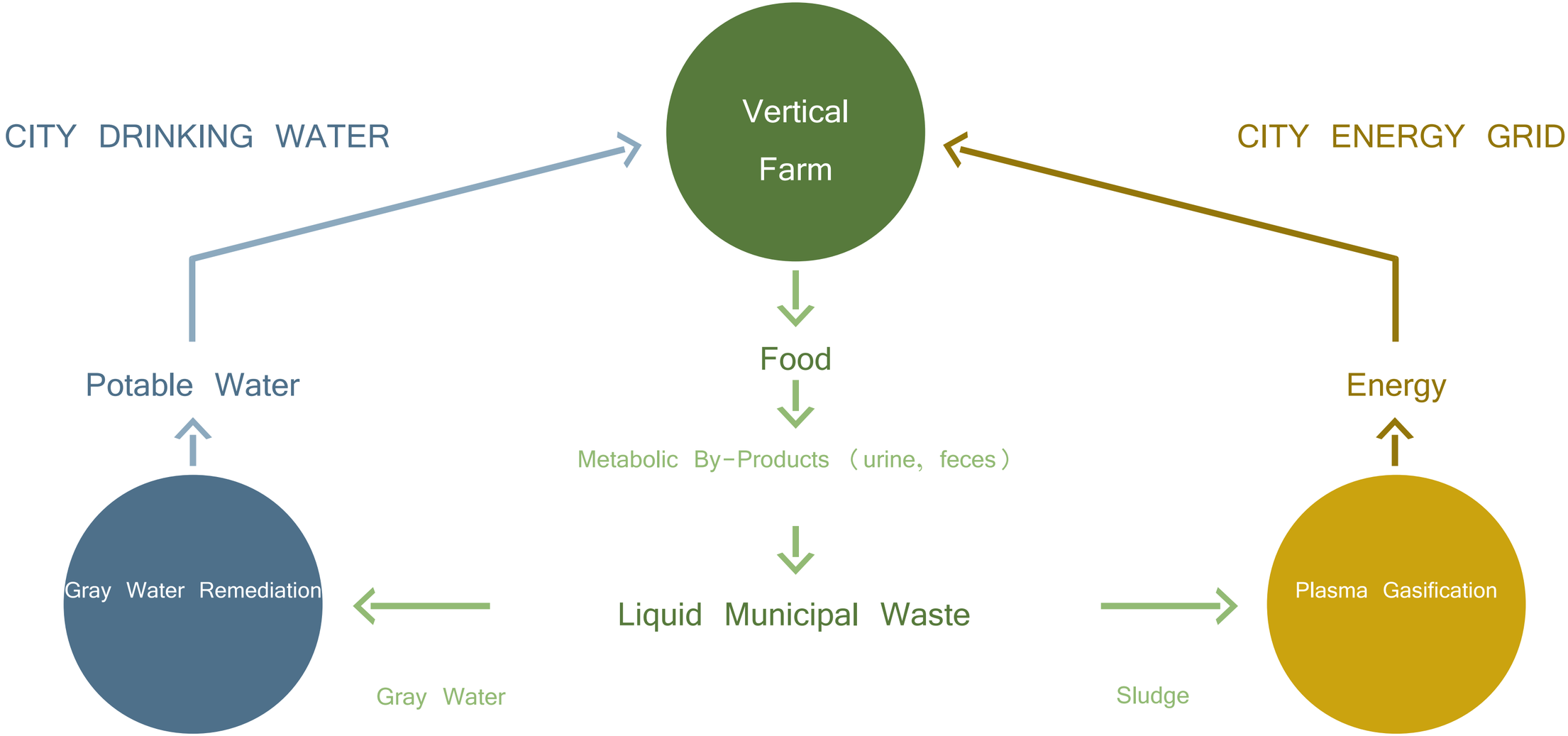
Water Re-capture

Passive Energy

LED Lighting

The Sustainable Eco-City

(employs cutting-edge technologies)



Can we actually

do any of this??

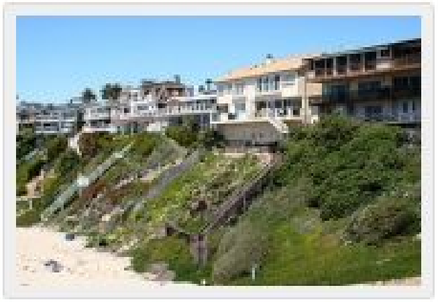
We are already doing it!

Santa Ana, California

Black water Gray water Drinking water

Toilet to Tap: Orange County Turning Sewage Water into Drinking Water

Posted on Mar 14, 2009 by Jennifer Lance in Availability, Drinking Water, Infrastructure, Purification



The Orange County Water District is purifying wastewater into drinking water at a $481 million recycling plant. The plant uses microfiltration, reverse osmosis, ultraviolet light, and hydrogen peroxide disinfection. 70 million gallons of sewer water is treated a day in Orange County, California meeting the drinking needs of over 500,000 people, including visitors to Disneyland.

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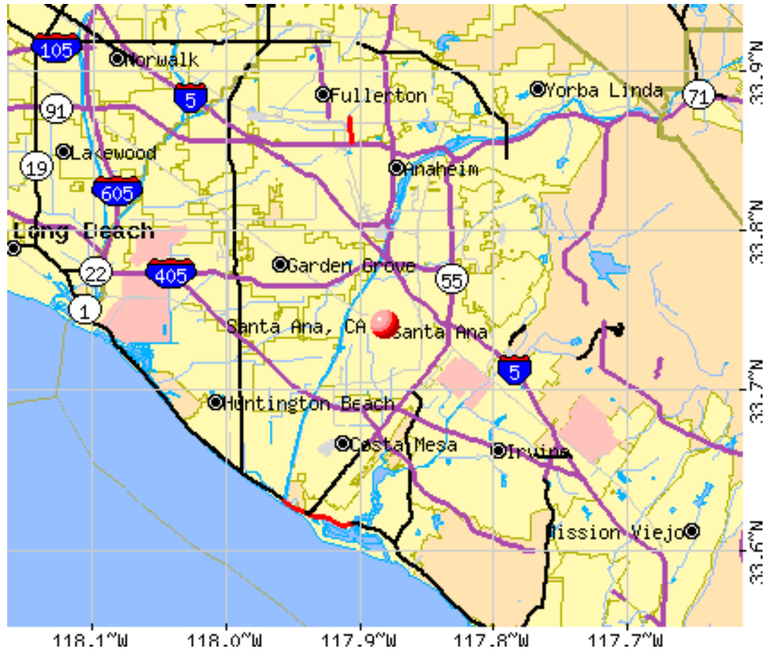
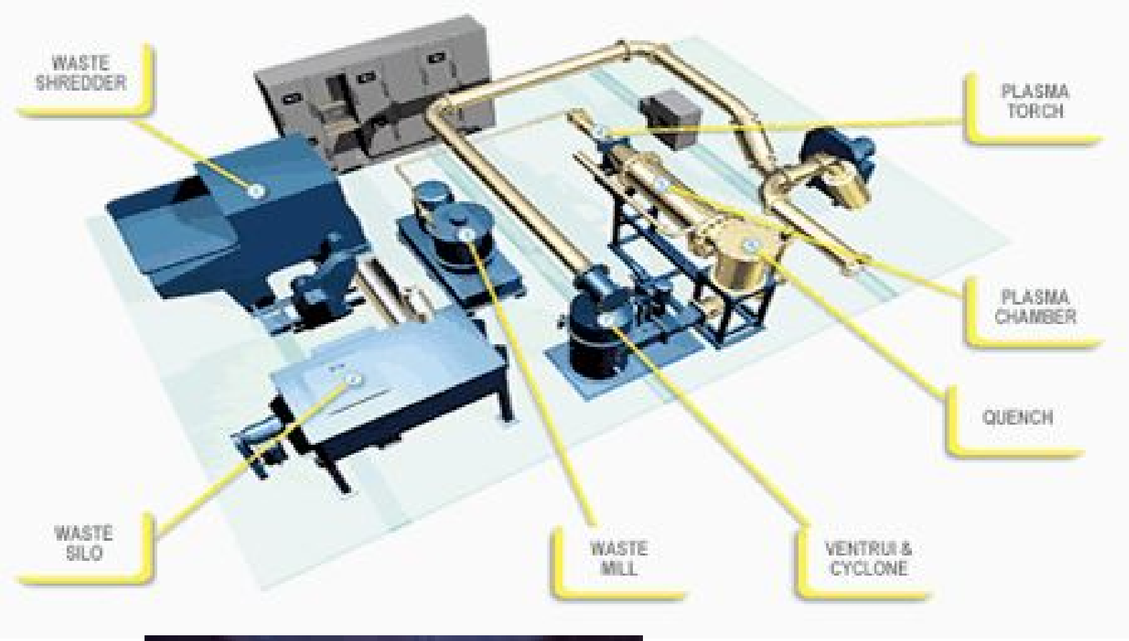
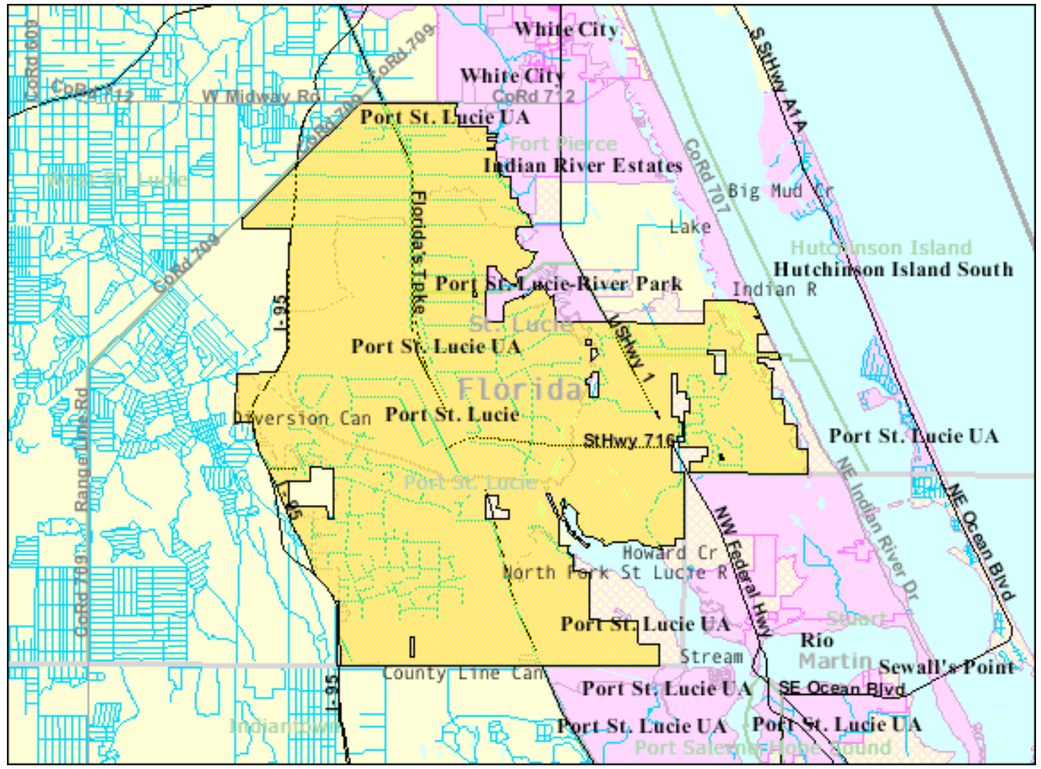


Port St. Lucie, Florida



Plasma Arc Gasification



1,500 tons of solid municipal waste/day!

TITLE

Dubai Pyramid Farm

ILLUSTRATOR

Eric Ellingsen

Dickson Despommier

LOCATION

Dubai

TITLE

Pla(n)tform:
An alternative for urban growth

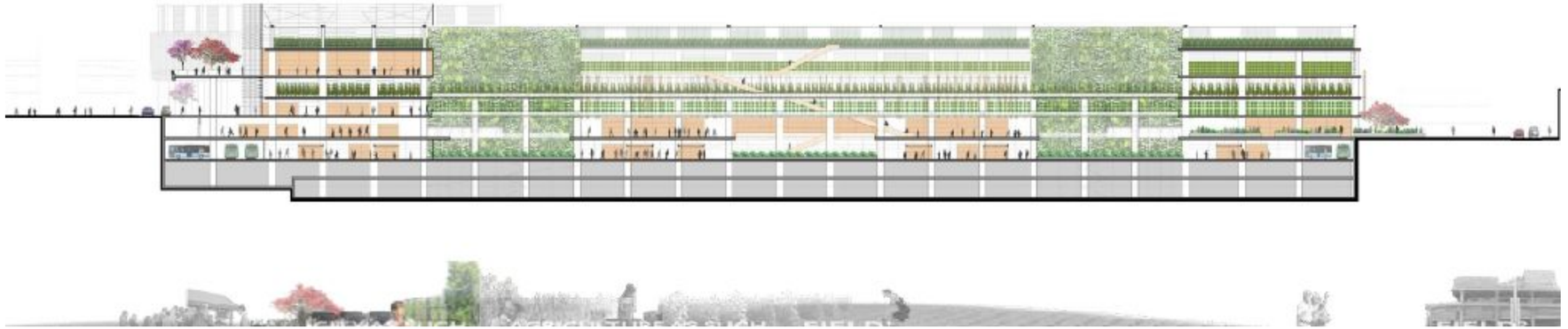
ILLUSTRATOR

Ori Ronen &
Adi Reich

LOCATION

Tel Aviv, Israel

East-West Longitudinal Section Through Northern Wing



TITLE

Pla(n)tform:
An alternative for urban growth

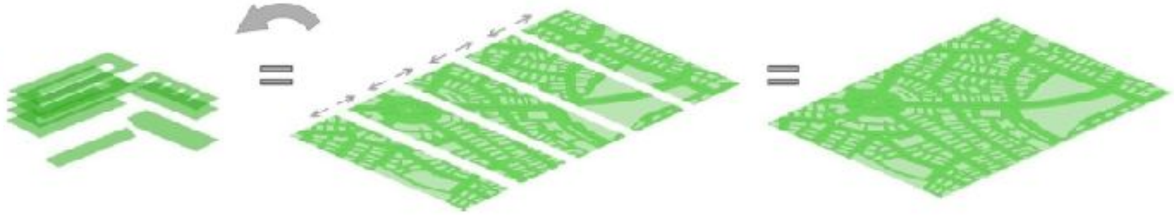
ILLUSTRATOR

Ori Ronen &
Adi Reich

LOCATION

Tel Aviv, Israel

Field Stacking: 40 acres of crops on 6 levels >> 827 tons of fruit and vegetable produce - approximately the consumption of the Neve Sha'anan and part of the Shapira neighborhoods.



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Pla(n)tform:
An alternative for urban growth

ILLUSTRATOR

Ori Ronen &
Adi Reich

LOCATION

Tel Aviv, Israel

TITLE

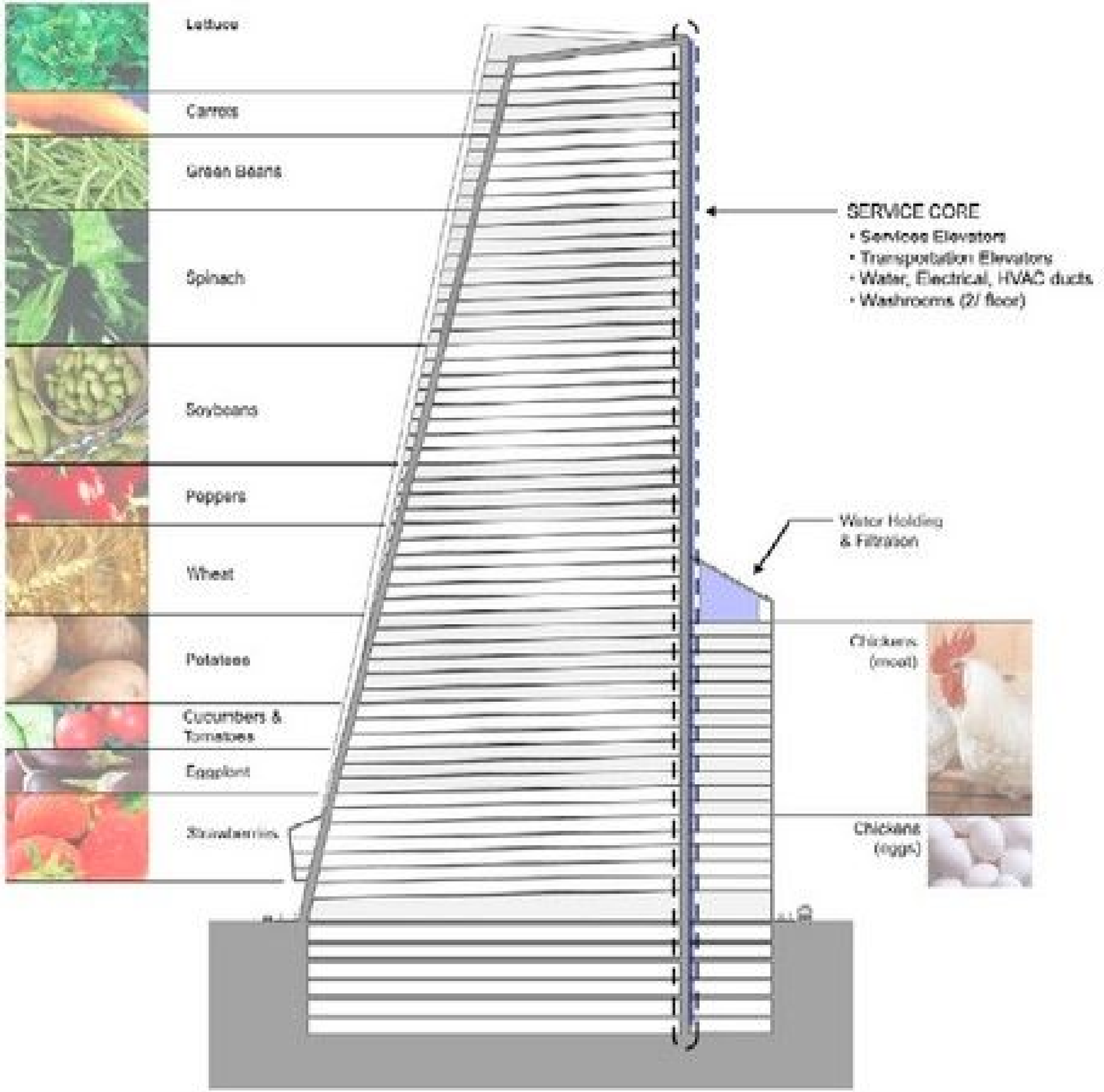
Vertical Farm

ILLUSTRATOR

Gordon Graff

LOCATION

Toronto, Canada



TITLE

Vertical Farm

ILLUSTRATOR

Gordon Graff

LOCATION

Toronto, Canada

TITLE

City of the Future

ILLUSTRATOR

Fougeron Architects

LOCATION

San Francisco, CA

TITLE

Vertical Farm

ILLUSTRATOR

Blake Kurasek

LOCATION

Chicago, IL

TITLE

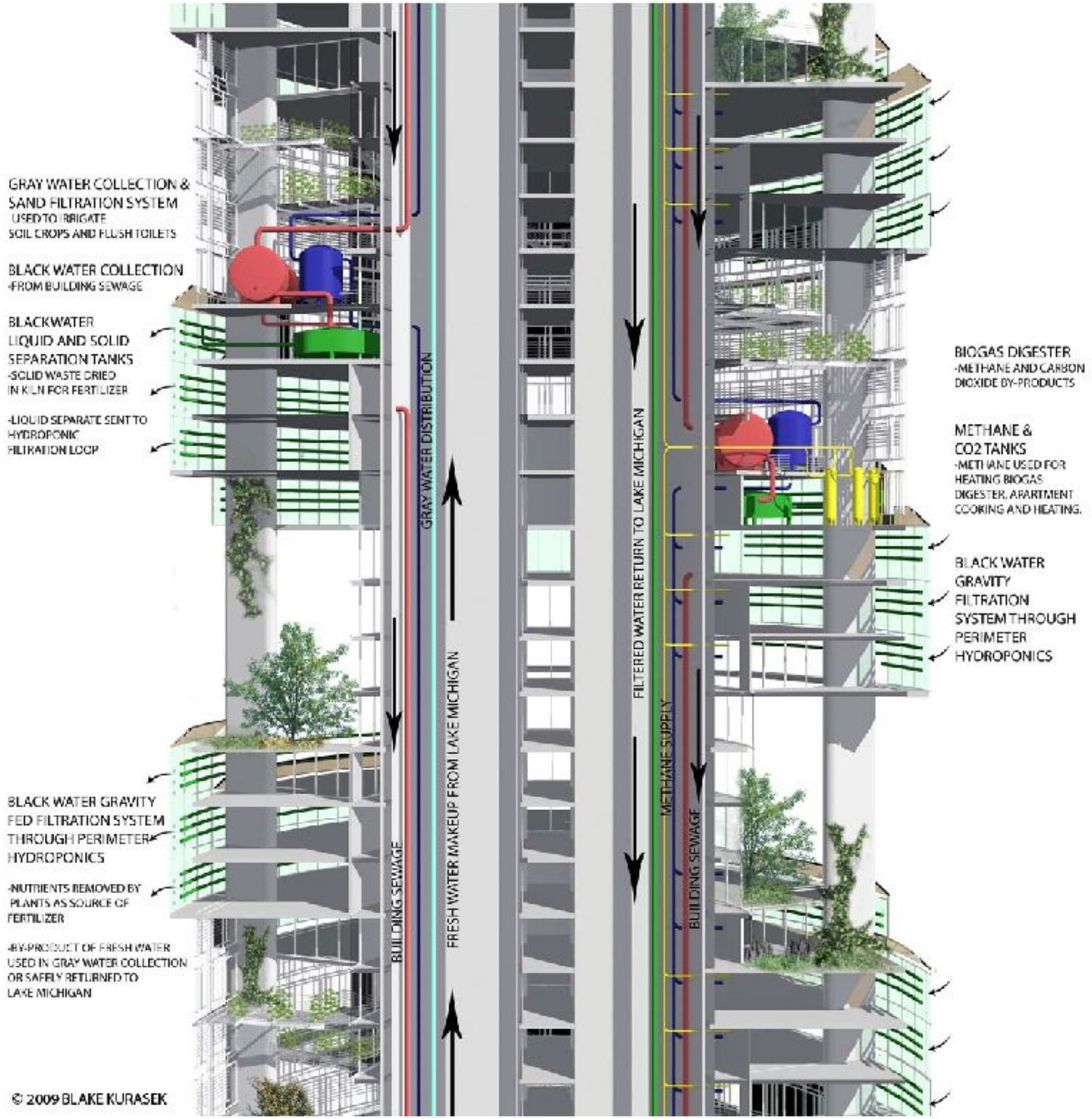
Vertical Farm

ILLUSTRATOR

Blake Kurasek

LOCATION

Chicago, IL



TITLE

Vertical Farm

ILLUSTRATOR

Blake Kurasek

LOCATION

Chicago，IL

TITLE

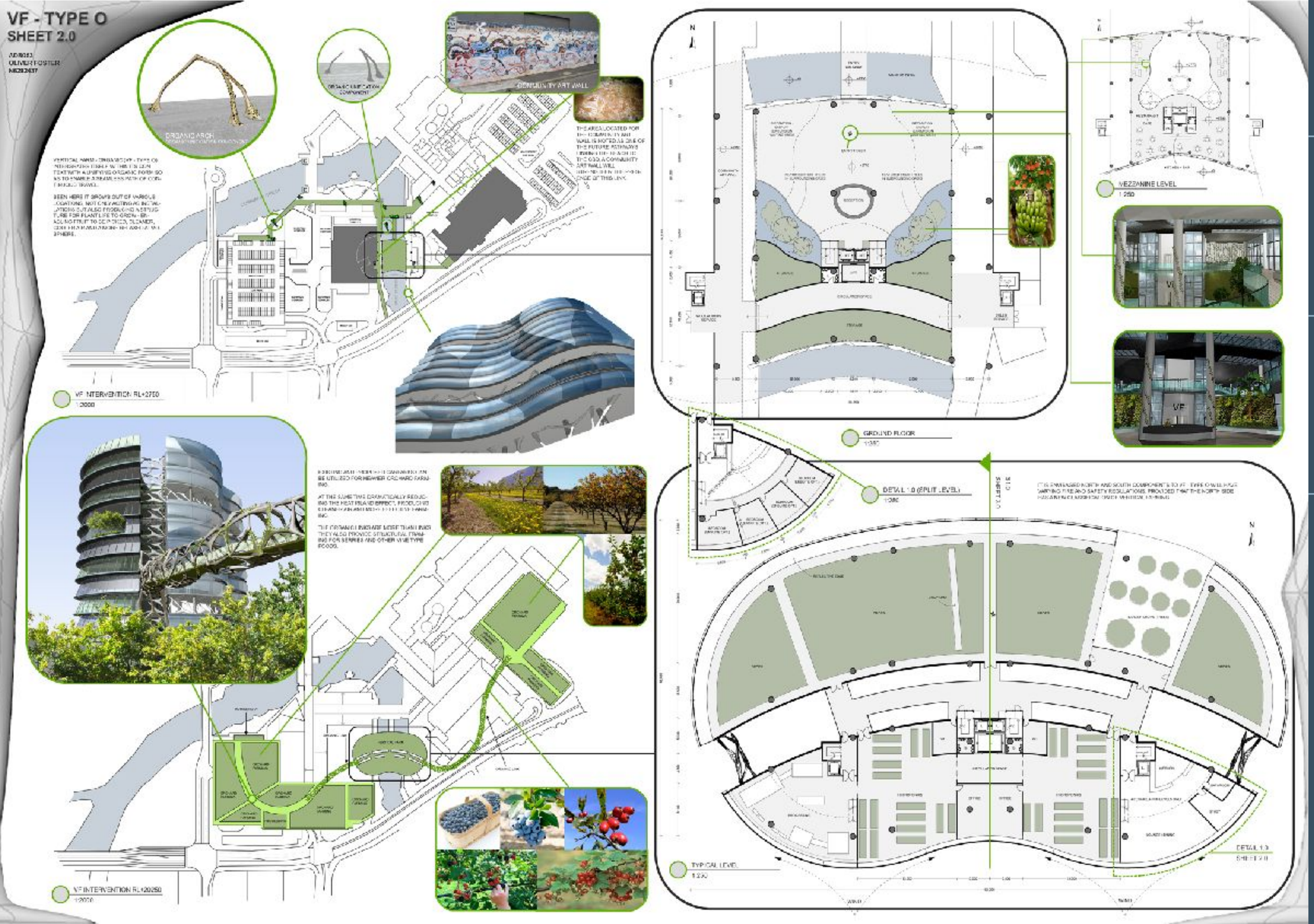
Vertical Farm

ILLUSTRATOR

Owen Foster

LOCATION

Queensland，Australia



TITLE

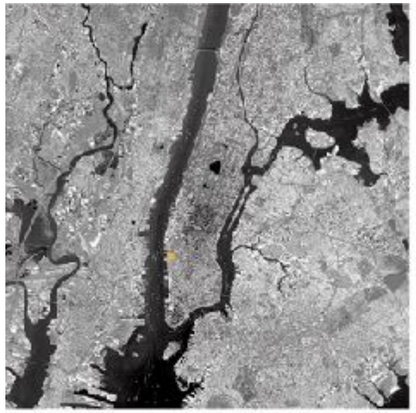
Vertical Farm

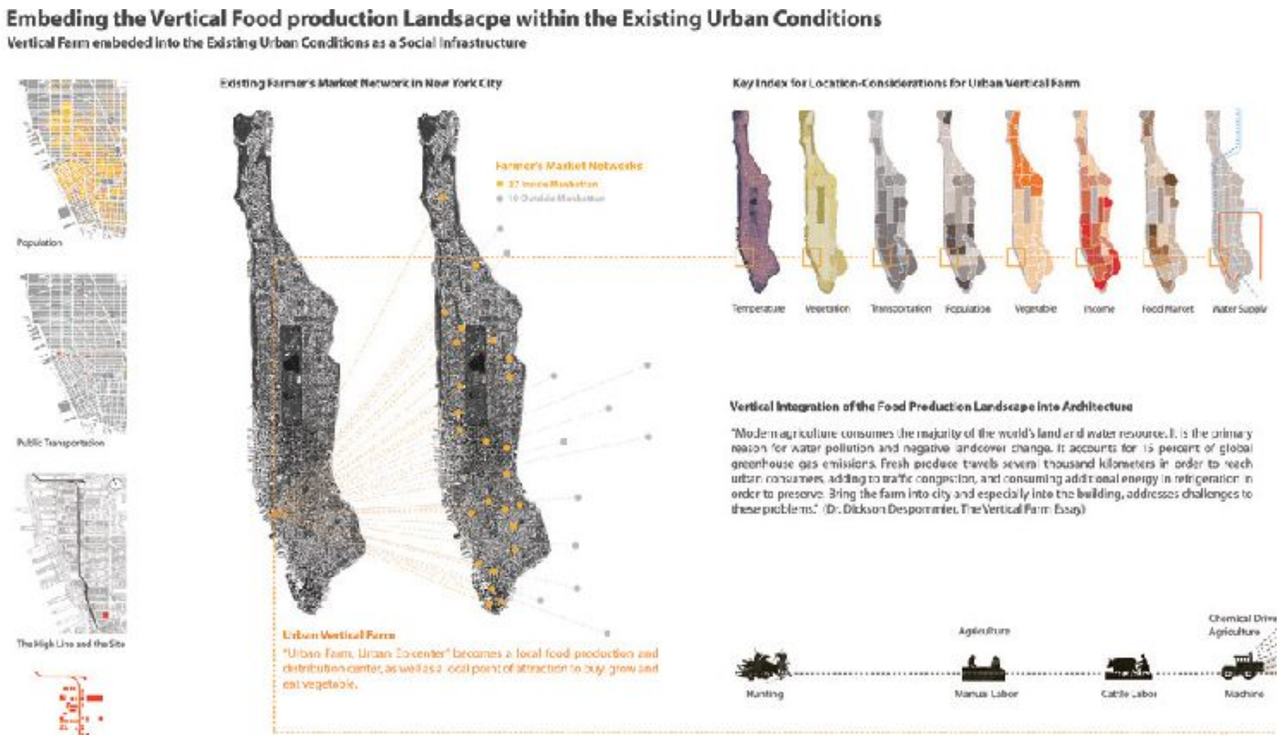
ILLUSTRATOR

Owen Foster

LOCATION

Queensland, Australia





TITLE

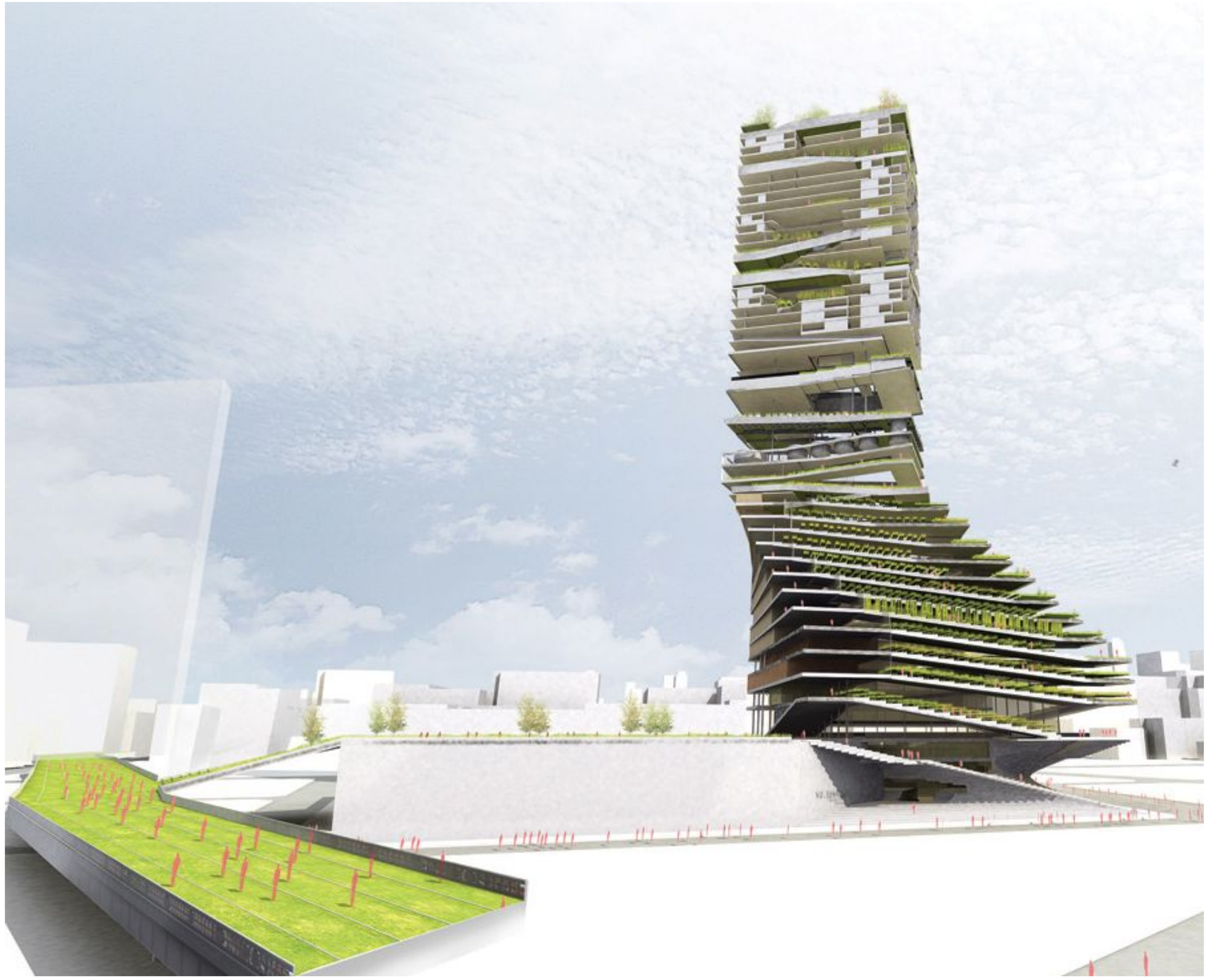
Urban farm,
urban epicenter

ILLUSTRATOR

Jung Min Nam

LOCATION

New York City



TITLE

Urban farm,
urban epicenter

ILLUSTRATOR

Jung Min Nam

LOCATION

New York City

TITLE

Urban farm, urban epicenter

ILLUSTRATOR

Jung Min Nam

LOCATION

New York City

TITLE

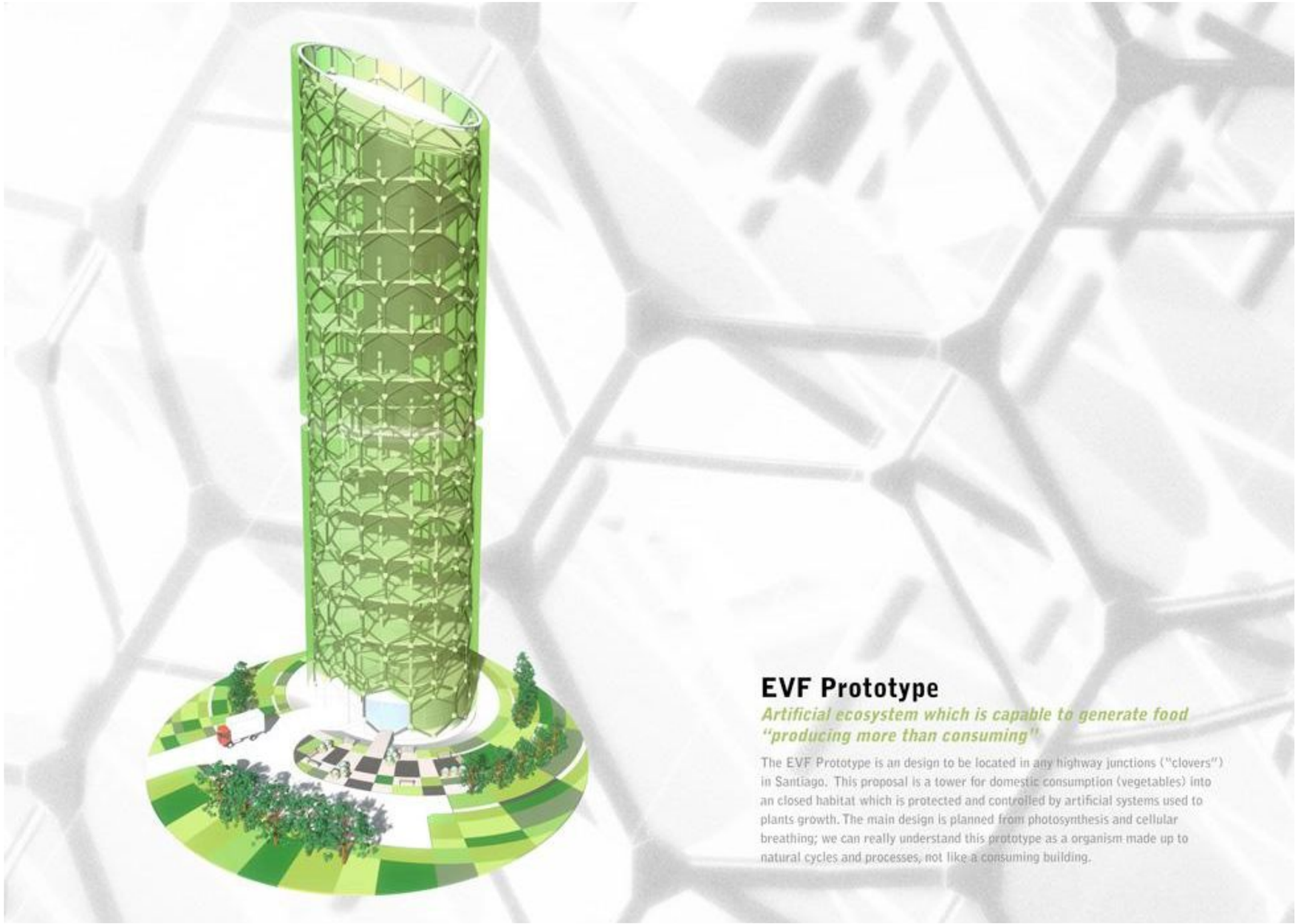
Experimental
Vertical Farm

ILLUSTRATOR

Claudio Palavecino
Llanos

LOCATION

Santiago, Chile



TITLE

Experimental Vertical Farm

ILLUSTRATOR

Claudio Palavecino Llanos

LOCATION

Santiago, Chile

TITLE

Experimental Vertical Farm

ILLUSTRATOR

Claudio Palavecino Llanos

LOCATION

Santiago, Chile

Technology

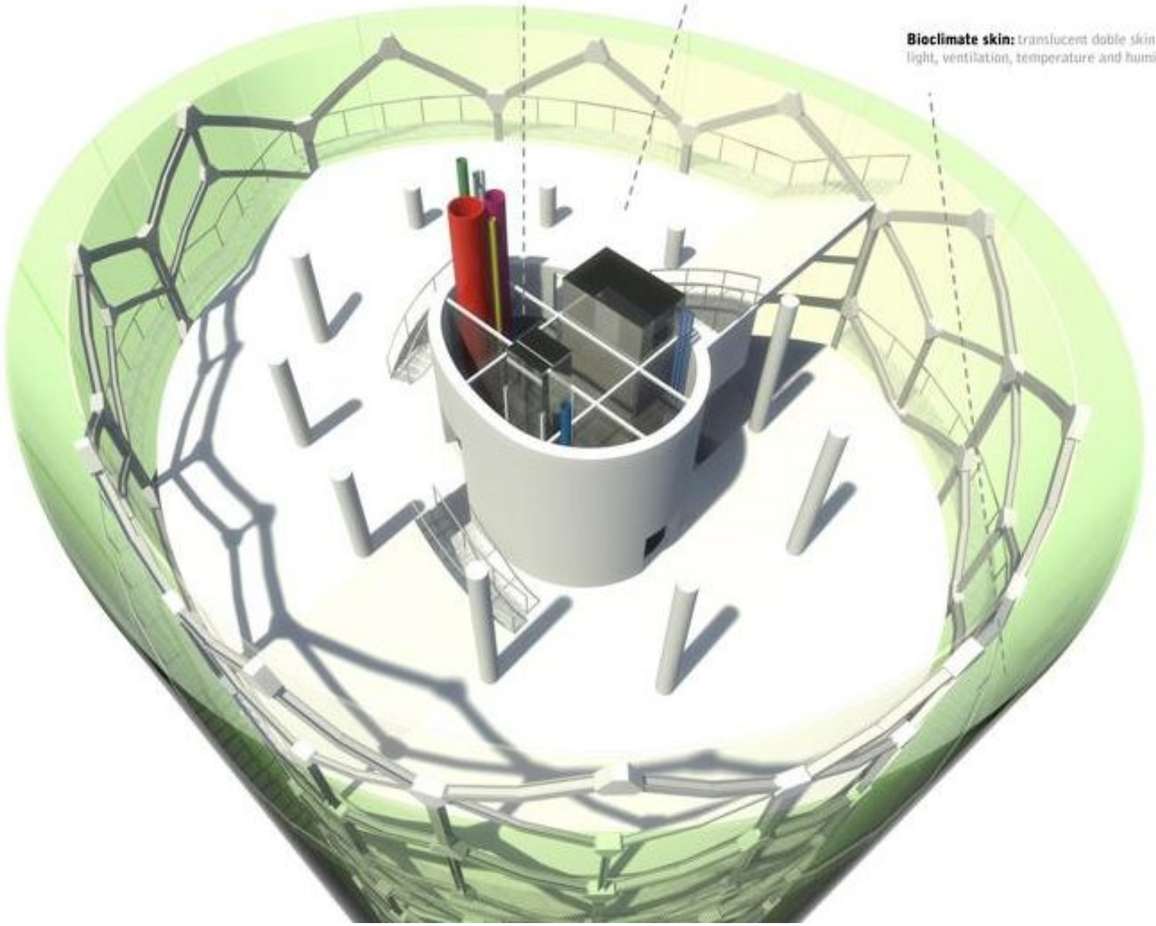
Matters and natural flows as design elements: building as a "living environment"

The crop unit emerges from relations between critical factors which make vegetable habitat maintenance an enable environment: air, humidity and sunlight. We don't understand matter and energy flows like external resources which feed the building; in fact, this factors form the operative program and building functioning.

Central core: is the dull zones where are main shafts to liquid pumping from water pumps, storage facilities, freight elevators and walkways.

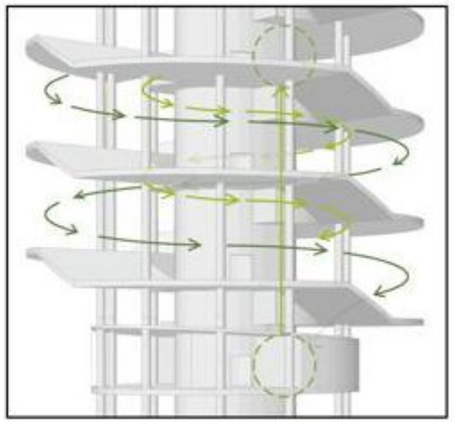
Crop areas: Continuous area leveled in different heights, like an spiral. This surface allows water falling to irrigate crops by gravitation, plus this space keeps a continuous air flow and diffuse light between levels.

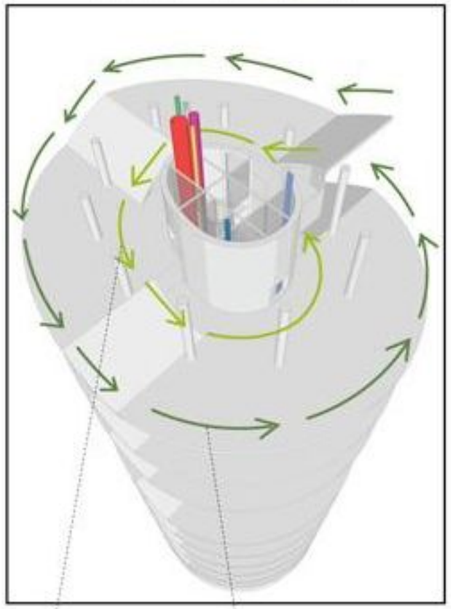
Bioclimate skin: translucent doble skin controls light, ventilation, temperature and humidity.



+ Humidity

Irrigation water rises up by water pumps, then water flows by pipes by gravitation, without energy consumption; this process is possible by the spiral form between levels. The perimetral skin catches water from evaporation – perspiration from inside vegetables to recycle.





Gotter systems to catch water from inside skin..

Pipe system to irrigate by gravitation

TITLE

Experimental Vertical Farm

ILLUSTRATOR

Claudio Palavecino Llanos

LOCATION

Santiago, Chile

TITLE

Museum of Science and Industry

LOCATION

Chicago，IL

TITLE

Illinois Institute of Technology, College of Architecture

DESIGNERS

Vertical Farm Model Team

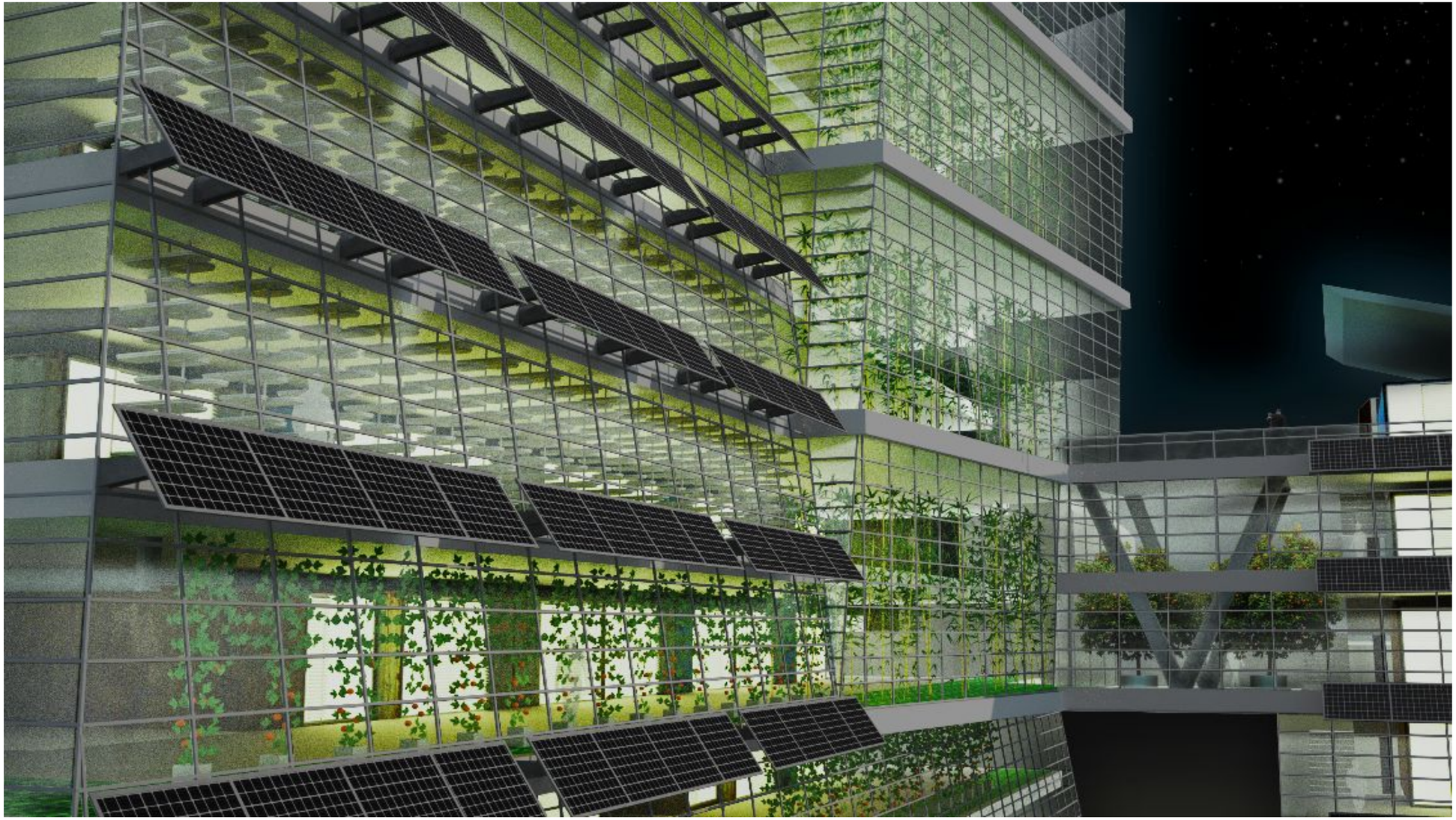
LOCATION

Chicago, IL.

First Create a Prototype

Weber Thompson – Seattle

Weber Thompson - Seattle



TITLE

Grade School Vertical Farm Project

ILLUSTRATOR

Tom’s Students

COLUMBIA UNIVERSITY

A Special Thanks to All My Students

2004
Anisa Buck
Daniel Dine
Stacy Goldberg
Vani Gulate
Vivek Iyer
Ben Jacob
Eugene Kang
Roger Kim
Jennifer Montes
Pearl Moy
Anita O'Connor
Katerina Paraskevas
Rebecca Tatum
Carrie Teicher
Janice Turner

2005
Alam Saad
Kristen Coates
Stephen Lee
Maribeth Lovegrove
Michelle Robalino
Theodora Sakata
Dennis Santella
Sapna Surendran
Kelly Urry

2006
James Baumgartner
Jasmine Beria
Kenneth Chamber
Elizabeth Del Giacco
Leslie-Anne Danielle Fitzpatrick
Bryan Joshua Garber
Greg Gin
Alexis Katrell Harman
Rory E. Mauro
Jun Michjael Mitsumoto
Natalie Neu
Ivan Ramirez
Elizabeth Morgan Reitano
Kathleen Ann Roosevelt
Jordana Rothschild
Nicholas Sebes
Adireenne Sheetz
Sonia Demitrie Toure
Athina Vassilakis

2007
Evelyn Natalia Alvarez
Matthew Peter Bussa
Caroline Carnevale
Yana Chervona
Richele Lynn Corrado
Manisha Daswani
Jonathan Gass
Moshen Ghanefar
Kahterine Gifford
Sookyung Ham
JongJin Jo
Dianna Jones
Steven Kauh
Raeya Khan
Danille Kontovas
Cynthia Lendor
Jason Light
Kevin Lo
Diego Lopez De Castilla
Chrisytopher Martin
Mary Ann Popovech
Iris Anne Cruz Reyes
Yalini Senathirajah
Timon Tai

2008
Sarah Autry
Claudia Cujar
Geoffrey Garst
Erica Hahn
Schuyler Henderson
Carolyn Hettrich
Yuki Kaneda
Chris Karampahtsis
Hannah Kellogg
Mateusz Kruk
Gilma Mantilla
Karl Minges
Christopher Ovanez
Johanathan Stettin
Sarah Wishnek

COLUMBIA UNIVERSITY

A Special Thanks to All My Students （cont'd）

2009

Joshua Bernstock
Alisa M. Koval
Yanjuska Lescaille
Sara M. Miller
Jonathan P. Salud
Alexander T. Sonneborn
Naomi J. Sorkin
Sunny Uppal
Alexander T. Varga
Kate R. Weinberg
Daniel Yagoda
Zahira Zahid

2010

Juilee Prakash Barde
Jonathan Remy Camuzeaux
Michelle T. Chuang
Offira Shuly Gabbay
Elizabeth Ellen Hornyak
Lea Kiefer
Freda Robyn Laulicht
Allison Michelle Martineau
Genevieve Sophia Slocum
Ida Hui Suen
Iesha Wadala
Patrice Adele

It’s time to stop talking…

…and START DOING!

Save Water

Farm Smart

Help Keep Our Blue Planet Green !

Thank You!