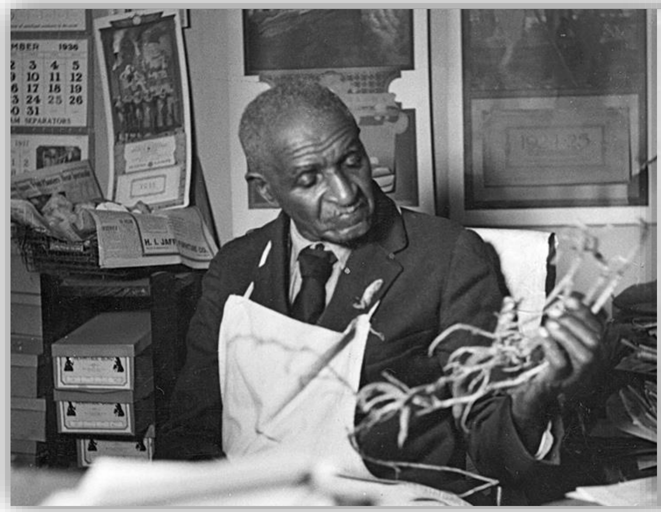
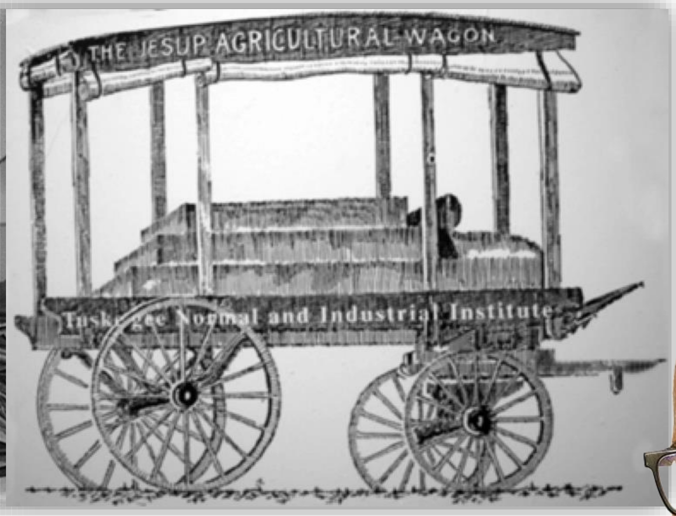
Bridging the Gap:
Technology Adoption in Small Holder Farms





Dr. Gregory C. Bernard
Tuskegee University

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AIFARMS
Artificial Intelligence for Future Agricultural Resilience, Management, and Sustainability

I-FARM: Farm of the Future

EARTHSENSE
AGRICULTURAL INTELLIGENCE

Center for Digital Agriculture

I-Regen
Regenerating health and wealth

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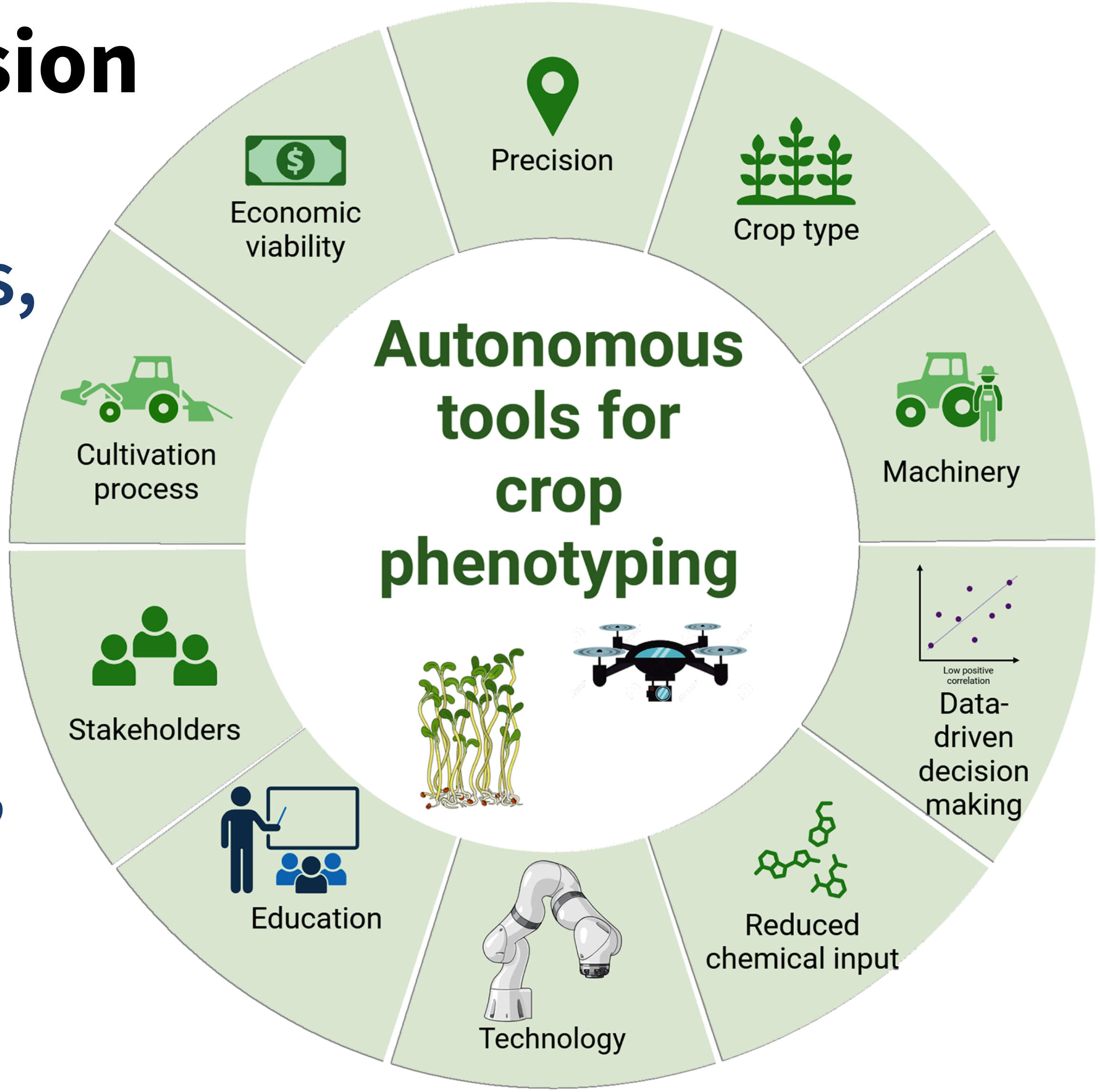
Project Relevance

Increased Efficiency and Precision

Enables early detection of pests, diseases, and nutrient deficiencies, reducing crop loss.

Cost-Effective

Reduces labor costs
while enhancing yield and quality, making technology accessible to small-scale farmers.



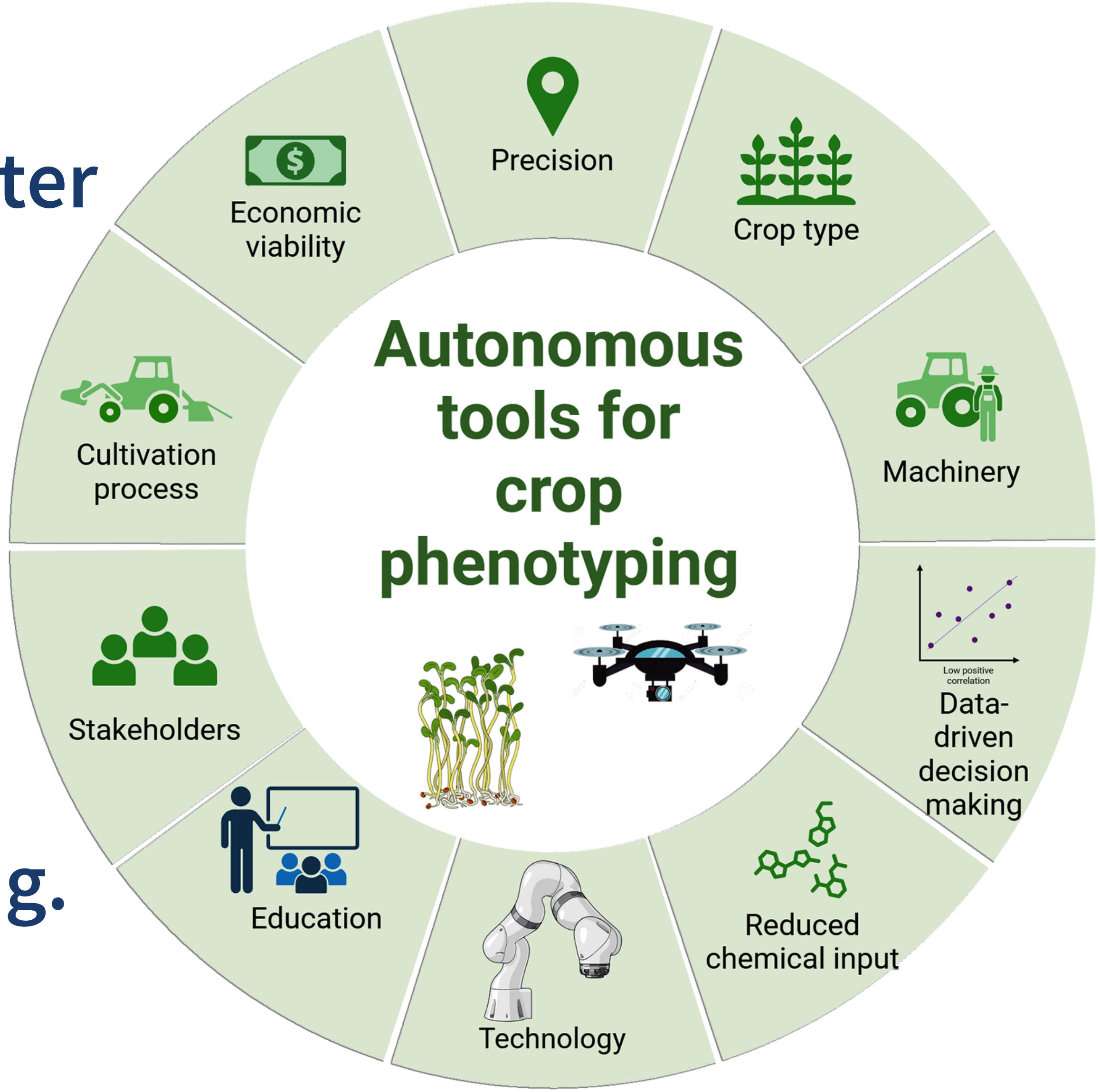
Project Relevance

Data-Driven Decisions

Provides real-time insights for better management of irrigation, fertilization, and pest control.

Sustainability

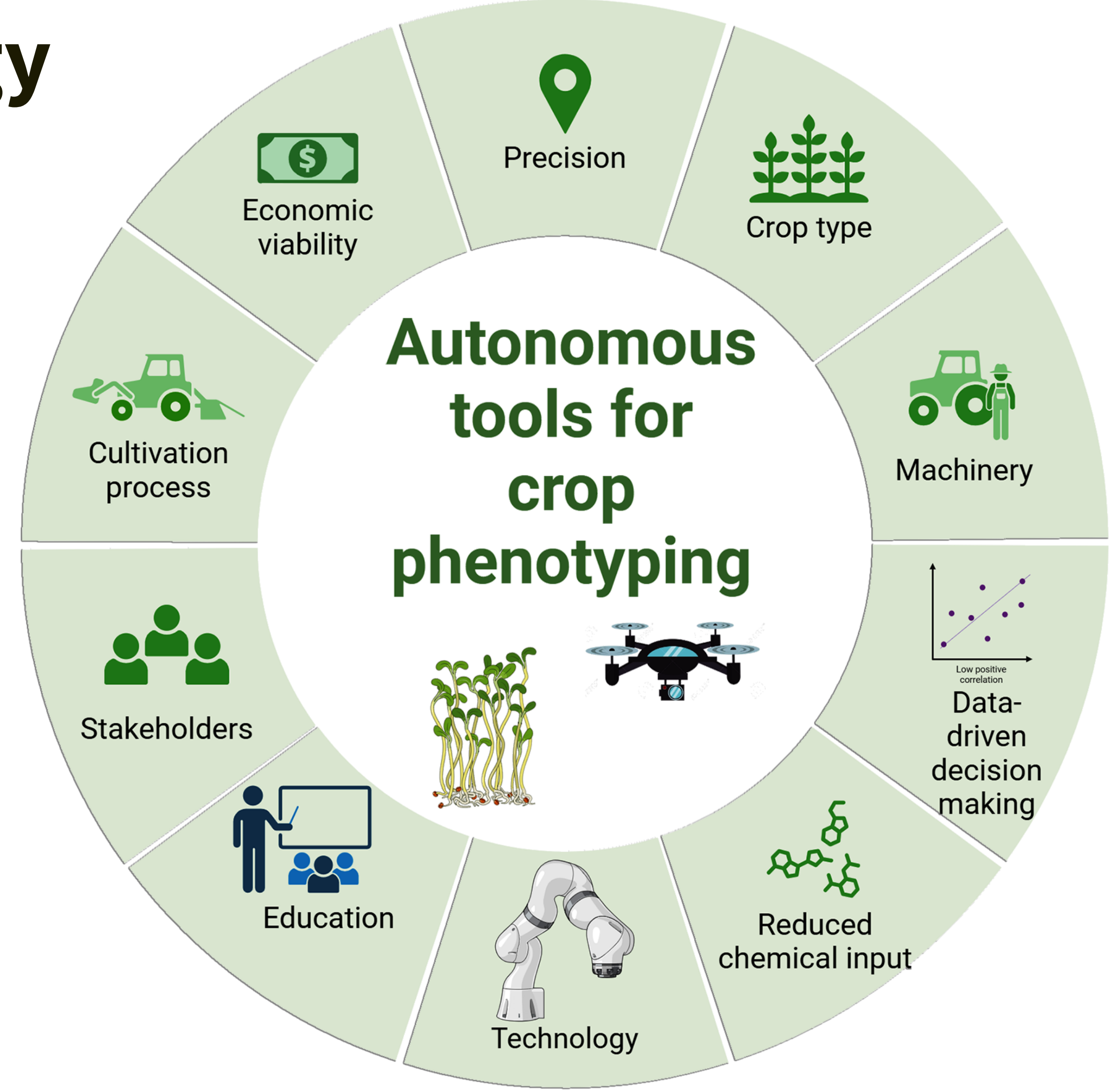
Optimizes resource use, minimizing environmental impact and promoting sustainable farming.



Project Relevance

Access to Advanced Technology

Levels the playing field by providing small-scale farmers with cutting-edge tools.



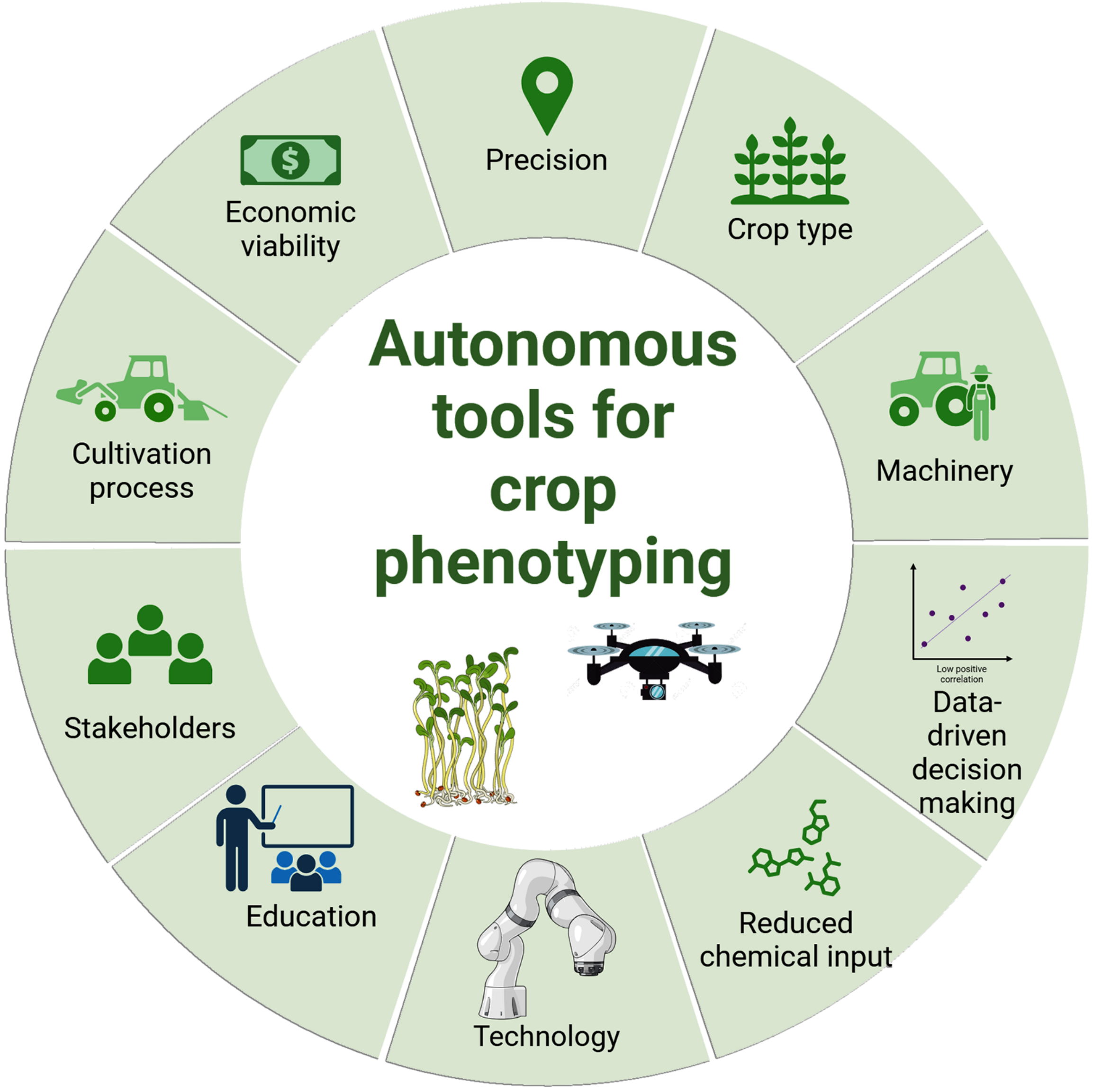
Project Relevance

Improved Productivity

Enhances crop performance and yield, contributing to food security.

Educational Benefits

Supports experiential learning for farmers and students, driving innovation in local communities.



AIFARMS
AI for Future Agricultural Resilience, Management, and Sustainability

Collaborative effort

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Andrea Eveland

MICHIGAN STATE UNIVERSITY


Bruno Basso

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Introduction to Plant Phenomics

- **Plant phenomics** involves the study of plant traits (phenotypes) using high-throughput technologies.
- Automation is essential to increase efficiency and accuracy in data collection.
- Applications include crop improvement, stress response analysis, and resource optimization.

Automation in Crop Phenotyping

- Overcomes limitations of manual phenotyping, such as labor intensity and time consumption.
- Enhances scalability & reproducibility.
- Enables real-time data collection and analysis.
- Provides insights for precision agriculture and breeding programs.

https://clearpathrobotics.com/blog/2023/06/university-of-texas-at-arlington-employs-husky-ugv-for-automated-plant-phenotyping/

UNIVERSITY OF TEXAS AT ARLINGTON EMPLOYS HUSKY UGV FOR AUTOMATED PLANT PHENOTYPING

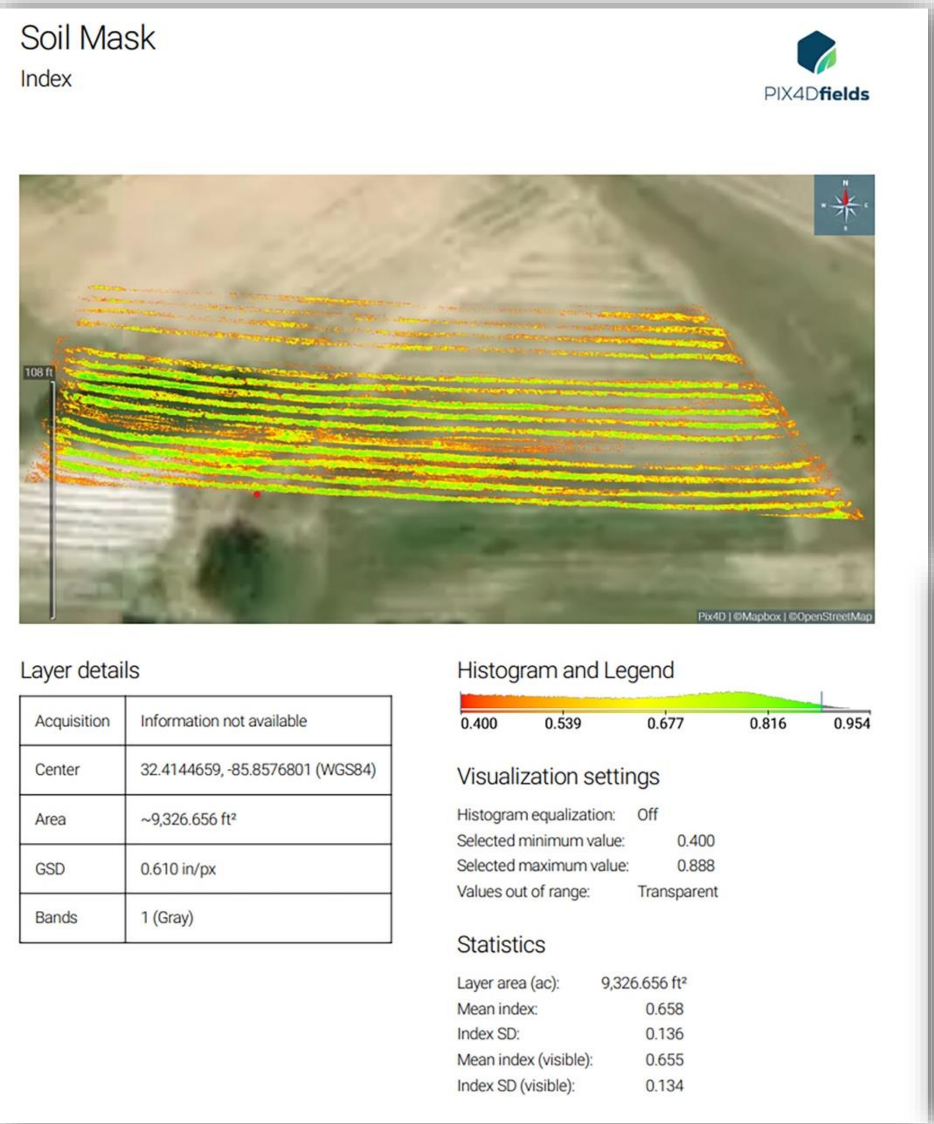
by Sophia Munir | Jun 12, 2023 | Blog, In the Field: Customer Spotlight |

Precision plant phenotyping is an essential practice for breeders to make informed decisions to meet the demands of modern agriculture and to contribute to resilient and sustainable crop production.

Decades of extensive research has resulted in the establishment of genetic resources for upland cotton, a globally significant crop that holds tremendous economic importance. With a staggering $123 billion impact in the United States annually, cotton production contributes significantly to global trade and the textile manufacturing industry. In this context, cotton phenotyping assumes a crucial role by equipping agronomists with high quality data and valuable insights which further advances research in the field.

There is an urgent need for advanced technologies, such as robotics and computer vision, that can precisely capture plant phenotypes. With the advent of these technologies, wide scale genomic selection and cotton breeding can be undertaken. To achieve this goal, a team of researchers at the Robotic Vision Laboratory (RVL) at the University of Texas at Arlington is using Husky UGV for automated cotton phenotyping.

Outreach & Extension: Bridging the technology gap to small-scale and minority farmers



Soil Mask
Index

PIX4Dfields

Pix4D | ©Mapbox | ©OpenStreetMap

Layer details

Acquisition	Information not available
Center	32.4144659, -85.8576801 (WGS84)
Area	~9,326.656 ft²
GSD	0.610 in/px
Bands	1 (Gray)

Histogram and Legend

0.400 0.539 0.677 0.816 0.954

Visualization settings

Histogram equalization: Off
Selected minimum value: 0.400
Selected maximum value: 0.888
Values out of range: Transparent

Statistics

Layer area (ac): 9,326.656 ft²
Mean index: 0.658
Index SD: 0.136
Mean index (visible): 0.655
Index SD (visible): 0.134

Outreach & Extension: Bridging the technology gap to small-scale and minority farmers

Outreach & Extension: Bridging the technology gap to small-scale and minority farmers

Integration of technology On-Farm Small Holders

“Even before the onset of the COVID-19 pandemic, agricultural employers were struggling to secure a stable workforce”

USDA Farm Service Agency

Farm Labor Stabilization and Protection Pilot Grant Program

The Use of Autonomous Robots to Address Labor Demands and Improve Efficacy in Agriculture.
Bernard GC*, Bolden-Tiller O, Egnin M, Bonsi C, McKinstry A, et al.
COJ Rob Artificial Intel. 1(5). COJRA. 000523. 2022.
DOI: 10.31031/COJRA.2022.01.000523

Crimson Publishers
Wings to the Research

Mini Review

The Use of Autonomous Robots to Address Labor Demands and Improve Efficacy in Agriculture

Bernard GC[1]*, Bolden-Tiller O[1], Egnin M[1], Bonsi C[1], McKinstry A[1], Landon Z[1], Bob Chen YY[2], Inocent R[1], Archie T[1], Chowdhury S[1], Charleston C[1], Turner A[1], Brown A[1], Idehen O[1], Mitchell I[1], Boone J[1], Peterson C[1], Lockett A[1] and Mortley D[1]

[1]Department of Agriculture, College of Agriculture, Environment and Nutrition Sciences, Tuskegee University, Alabama, USA

[2]Institute for Genomic Biology, University of Illinois Urbana-Champaign, Illinois, USA

Abstract

Agricultural robots, or agribots designed for agricultural purposes, are becoming essential tools to improve efficiency by addressing critical constraints such as labor shortage, agricultural input and cost, and environmental monitoring. The incorporation of autonomous tools like crop propagation Farm BotTM and Terra SentiaTM field bot can improve agricultural production schemes by meeting specialized labor demands and providing field data analyses; thus, advancing numerous aspects of precision farming, potentially lowering production costs and reducing environmental impacts. These technologies are integrated with advanced detection and analytical methodologies to develop growth monitoring models to improve overall performance under precision farming protocols, supporting sustainability.

***Corresponding author:** Bernard GC, Department of Agriculture, Environment and Nutrition Sciences, Tuskegee University, Alabama, USA

Submission: January 03, 2022
Published: March 03, 2022

Volume 1 - Issue 5

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Farmer Demographics and Labor Constraints

Currently, small-scale farmers (less than $350,000 in gross cash farm income) comprise 90 percent of all U.S. farms [1]. White farmers (including Hispanics) account for 95.4% of this group, while Hispanic or Latino farmers make up 3.3% of producers, followed by 1.7% identified as American Indian or Alaskan Native and 1.3% Black. One of the significant constraints faced by these farmers is labor costs, which can represent up to forty percent of the total variable costs for vegetable and fruit crop production [2]. A recent survey conducted by the California Farm Bureau Federation reported that 55% of responding farmers had experienced employee shortages, including 69% of farmers who hire due to seasonal needs [3]. Labor shortages are more impactful to farmers who require more exhaustive hand labor in production and harvesting, for example, for orchard and grape farmers. Improved labor-management strategies, thus, have become critical for the long-term sustainability of farms, especially for small-scale farmers that face increasing resource constraints and prohibited use of alternative labor sources (e.g., foreign workers) [4].

Agricultural Robots

Agribots are autonomous, decision-making, mechanized technologies that perform routine and specialized tasks in agricultural production schemes under human supervision without direct human labor [5-7]. Autonomous crop equipment (also known as crop robots) can potentially address labor constraints, global food security and reduce the environmental footprint of agriculture [5,8,9]. Additionally, in the U.S. and U.K, farm labor has decreased significantly due to the COVID-19 pandemic [10] and the restriction to address its transmission. Incorporating robots and autonomous farming into precision farming protocols for the modern farmer was envisioned long ago [7]. Autonomous robots, including “farm bots” and “field bots,” are equipped with cameras, sensors, and mechanical arms (field bots) to help identify potential areas of concern in farming production, including disease monitoring, water management, and nutrient availability, as well as harvesting. The Farm Bot (Figure 1), developed by Rory Aronson et al., is an open-source precision agriculture tool equipped with a camera and several tool-mounts for planting, weeding, soil moisture sensing,

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ROBOTICS INTEGRATED HIGH TUNNELS (ROBINHIGHTS): CREATING PROFITABLE FOOD OASES IN URBAN ECOSYSTEMS

Objective

Urban farms can enable efficient and fresh local food production, minimize food miles, and open new avenues of income for minorities and small communities. However, urban farms face unique challenges associated with achieving profitability at small production scales, maintaining air and soil quality, irrigation, pest management and the climate required for efficient and economically viable produce. In this project, we emphasize High Tunnels (HTs), which are low cost, unheated, metal-tube structures covered with one or two layers of greenhouse plastic to create a protected environment for crops, as ideal solutions for urban farming. HTs are gaining in popularity as they prolong the production season especially in midwestern and northeastern climatic zones, increase yields and improve the quality of high-value specialty crops such as fruits, vegetables and cut flowers. The primary goal of the projectis to investigate the feasibility of robot-aided autonomy to streamline labor intensive operations in the urban setting. Specifically, the goal of the Robot Integrated High Tunnels (RobInHighTs) platform is to integrate recent advances in robot hardware design, vision-based perception, autonomous navigation, and manipulation towards automating high tunnel operations such as harvesting, pruning and pest management thereby achieving sustainable increases in yield and

Investigators

Krishnan, G.

Institution

UNIVERSITY OF ILLINOIS

Start date

2023

End date

2026

Funding Source

Nat'l. Inst. of Food and Agriculture

Project number

ILLU-000-685

Accession number

1029772

https://portal.nifa.usda.gov/web/crisprojectpages/1029772.html

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

G. Krishnan
N. Uppalapati
G. Chowdhary
S. Attallah
K. Athey

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G.C. Bernard
O. Bolden-Tiller
T. Gautam

Multifunctional crop robot

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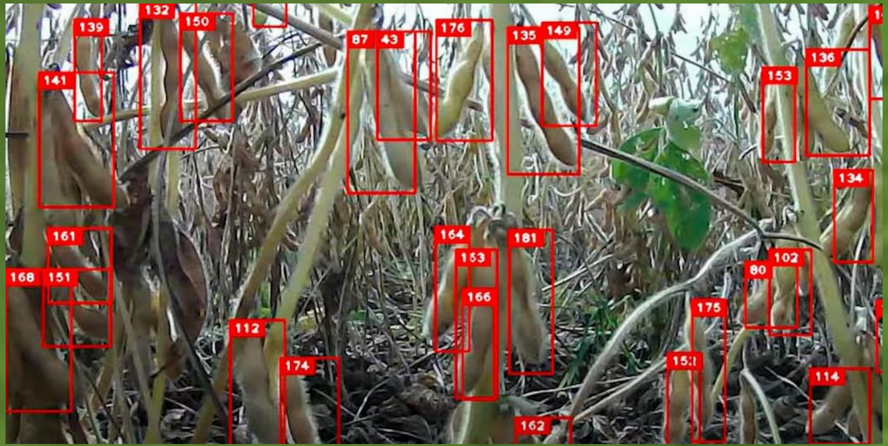
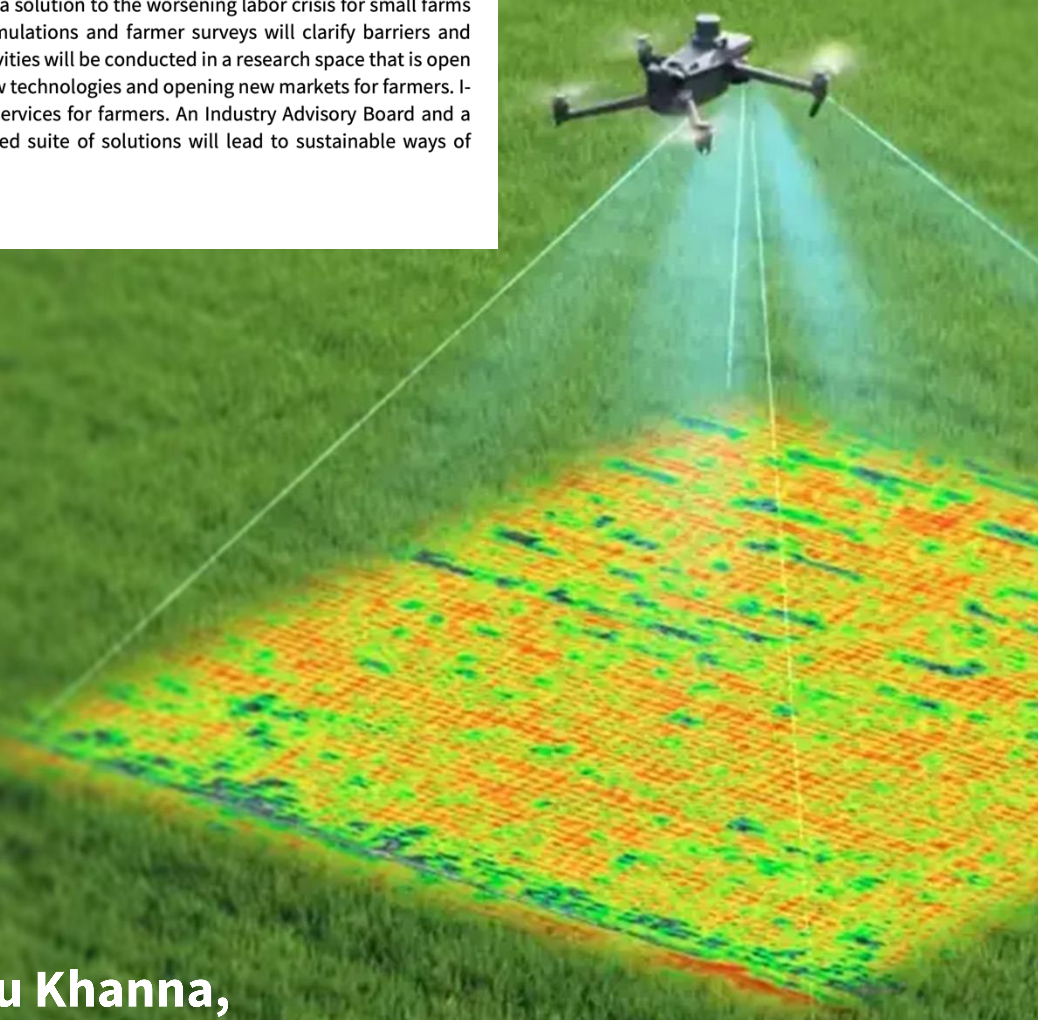
I-FARM: Illinois Farming and Regenerative Management Testbed

Overview: I-FARM (Illinois - Farming and Regenerative Management) testbed will accelerate creation, maturation, and adoption of new management technologies that are fundamentally more sustainable, profitable, affordable, and scale-neutral. I-FARM will provide comprehensive management practices for a farm-of-the-future and demonstrate their application on an 80-acre testbed. In the first three years, technologies matured will leverage existing strengths of our team, including improved precision farming with remote-sensing; new under-canopy autonomous robotic solutions for cover-crop planting, variable-rate input applications, and mechanical weeding; remote sensing technologies for animal health prediction; enabled by multimodal networking solutions for rural broadband connectivity and edge AI. The MyFarm app will provide farmers with an integrated dashboard that can be customized to the needs of their farm. Our focus on scale-neutral technologies can provide a solution to the worsening labor crisis for small farms and improve the sustainability of large and spatially heterogeneous farms. Technoeconomic simulations and farmer surveys will clarify barriers and incentives to adoption of sustainable technology to industry and farmers. Integrated extension activities will be conducted in a research space that is open to farmers, where farmers will be provided demonstrations and training, easing the adoption of new technologies and opening new markets for farmers. I-FARM team will engage with the Industry to help Industry create new data-driven products and services for farmers. An Industry Advisory Board and a Farmer Advisory Board will help optimize impact on farming practices. Together, these integrated suite of solutions will lead to sustainable ways of meeting growing demand for agricultural produce.

Principal Investigator: Dr. Girish Chowdhary





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O. Bolden-Tiller
G. C. Bernard

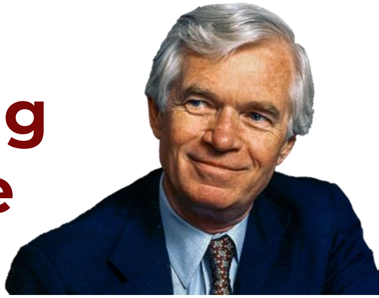
Center for Digital Agriculture

Girish Chowdhary, Kaiyu Guan, Madhu Khanna,
Isabella Condotta, Deepak Vasisht, and Salah Fuad Issa

Outreach and engagement

Tuskegee University Farmers Conferences 2023
Dennis Bowman and Dr. Salah Fuad visit (UIUC)

9/2024 The Cochran Fellowship Program, named after the late U.S. Senator William Thad Cochran, provides short-term training opportunities to agricultural professionals from middle-income countries, emerging markets, and emerging democracies.



USDA Foreign Agricultural Service
U.S. DEPARTMENT OF AGRICULTURE

The Cochran Fellowship Program, named after the late U.S. Senator William Thad Cochran, provides short-term training opportunities to agricultural professionals from middle-income countries, emerging markets, and emerging democracies.

The goals are:

- to help eligible countries develop agricultural systems necessary to meet the food and fiber needs of their domestic populations; and
- to strengthen and enhance trade linkages between eligible countries and agricultural interests in the United States.

Contact

Global Programs

borlaugfellowships@usda.gov

Automated Crop Phenotyping Technologies: TerraSentia, terrestrial phenotyping rover

TerraSentia is a compact field robot designed for plant phenotyping.

I-FARM: Farm of the Future

Features:

- Measures traits like plant height, biomass, and canopy coverage.
- Operates autonomously in field environments.

Advantages:

- Lightweight and portable.
- High accuracy for close proximity measurements.

Watch the full video at https://www.youtube.com/watch?v=GK5ncp82je4

Source: https://earthsense.co/


BTW

Aerial crop monitoring using UAVs

Unmanned **A**erial **V**ehicles equipped with multispectral and hyperspectral cameras.

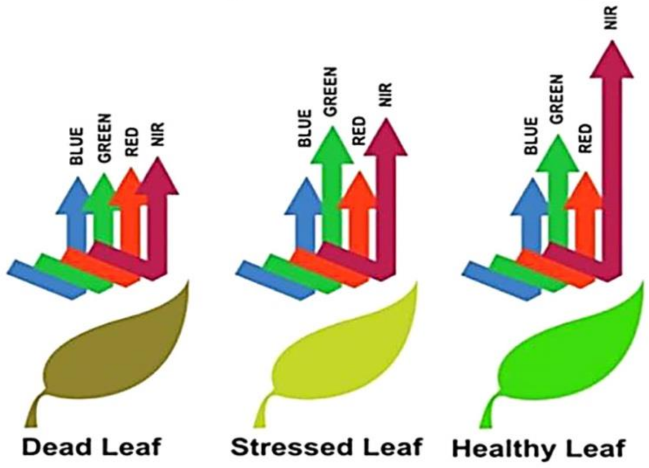
- Applications:
  - Large-scale monitoring of crop health.
  - Stress detection (e.g., water, nutrient deficiencies).
  - Mapping and yield estimation.
- Efficient means relative to "walking the back 40' (acres)

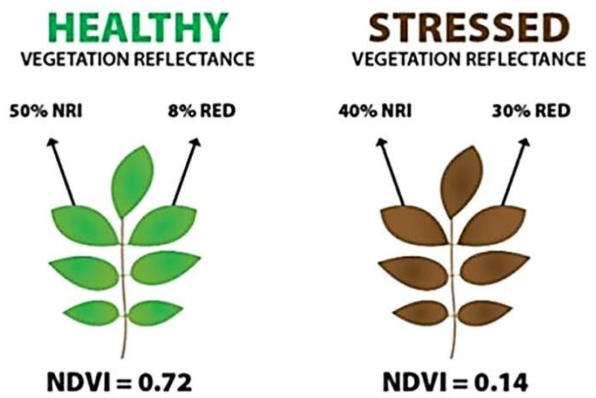
Source: https://phenomics.agron.iastate.ed

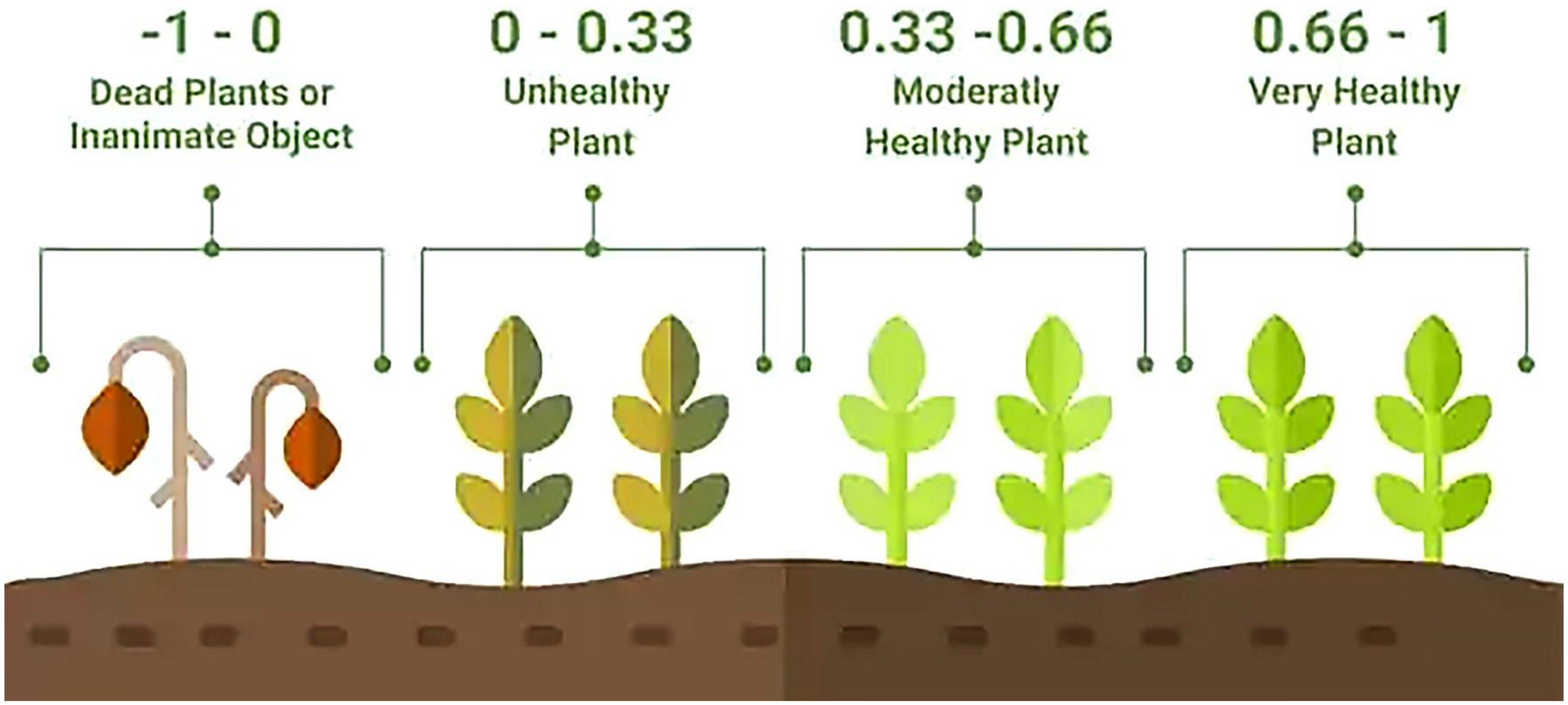
Leveraging Vegetative Indices for Advanced Plant Phenotyping: Insights into Crop Health and Stress Response

$$NDVI = \frac{(NearIR - Red)}{(NearIR + Red)}$$

Vegetative indices, like the **Normalized Difference Vegetation Index** (**NDVI**), measure plant health and vigor by analyzing light absorption and reflection in specific wavelengths



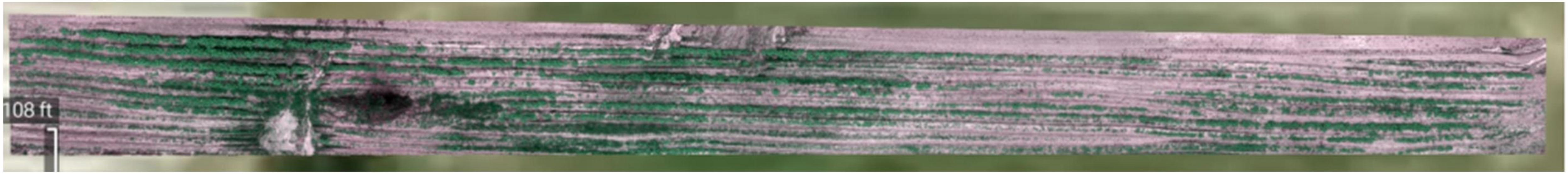




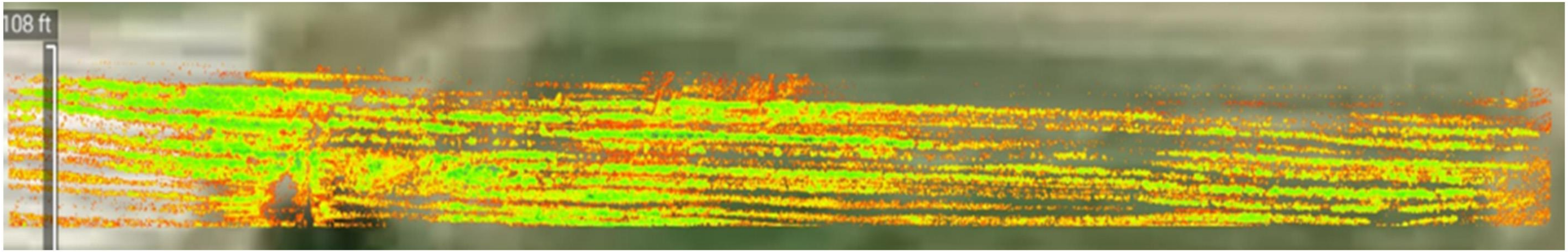
https://www.revistacanavieiros.com.br/o-que-sao-mapas-ndvi-e-como-utiliza-los-na-fazenda

Case Study
Crop Health Assessment
Hooks Farm, Shorter, AL

Orthomosaic of the Hooks Collards Field

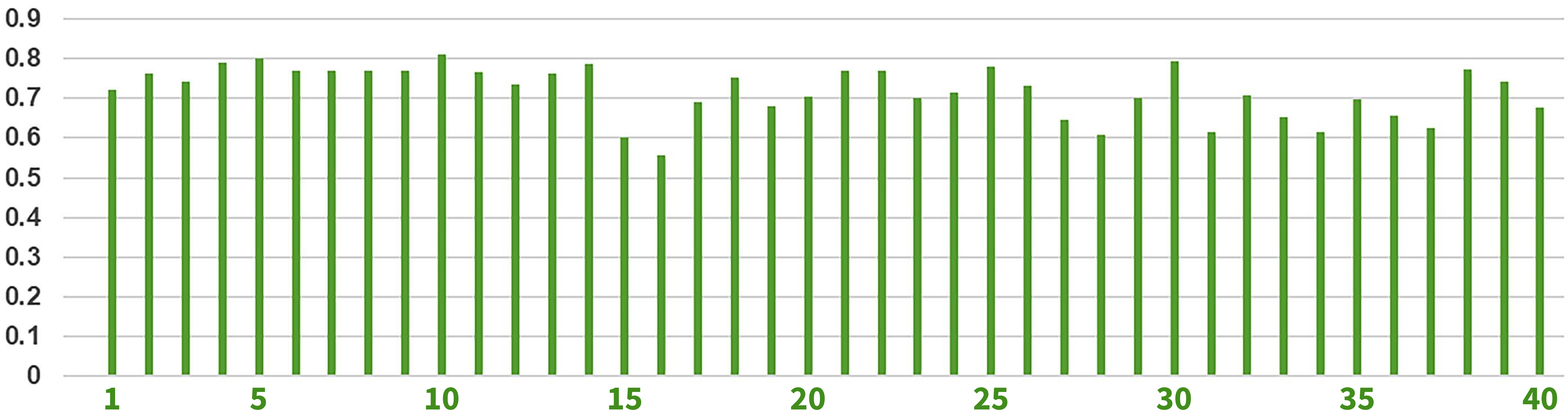


Soil Masked NDVI



Annotation

Soil Masked NDVI Values for Collards



Goals-Empowering Smallholder and Minority Farmers

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Expanding Crop Health Assessments and Innovative Phenotyping Technologies for Sustainable Agriculture.

Goals-Empowering Smallholder and Minority Farmers

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Student recruitment and training in crop health analyses


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Amiga by farm-ng

https://farm-ng.com/

Watch full video on farm-ng YouTube channel at
https://www.youtube.com/@farm-ng

Empowering the next generation of agriculture

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Understanding Behaviors in Housed Does by using Computer-Based Detection
Christian Peterson,1 Angela Green-Miller, 2 and Olga Bolden-Tiller1
Department of Agricultural and Environmental Sciences, Tuskegee University
University of Illinois at Urbana-Champaign
Abstract
Introduction
Objectives
Use Teachable Machine and training data set to train learning model for automatic detection of tail position in does
Materials & Methods
Selected one posture (erect tail) from ethogram while viewing preliminary video recordings
Recordings (8-10 min) were evaluated by a human observer and frames depicting tail position (erect tail; n=40 or down tail; n=40) were selected
Selected images (erect tail or down tail) were analyzed by using Teachable Machine
Results
AIFARMS
Thrust 2
USDA
Personalized Federated Learning
Problem Definition
RESULTS:
SUMMARY:
ACKNOWLEDGEMENT:
Thrust 1 : Open World AI
2023 AIFARMS CONFERENCE
Christian Peterson
Graduate Student
Tuskegee University
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What We Offer:

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- Hands-On Learning: Experience using autonomous robots and innovative agricultural technology
- Discussions on Crop health analysis

Who Can Join? Small-scale farmers, educators, and students interested in modern agricultural tools

No Cost for Farmers! Learn new techniques and robotics tools in precision agriculture!

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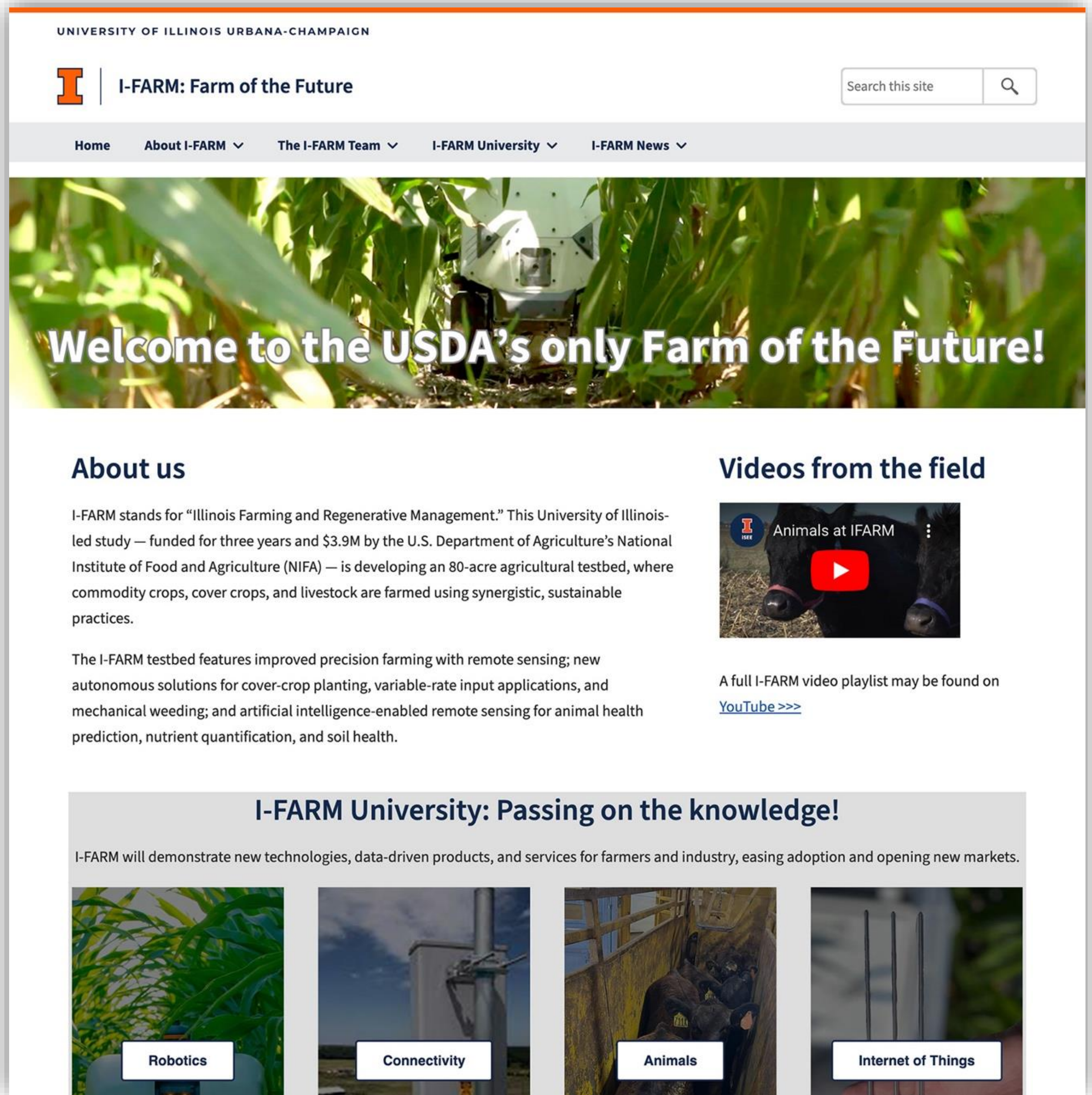
For more Information contact
Dr. Gregory C. Bernard
gbernard@tuskegee.edu
(334)-727-8401

i-farm.illinois.edu



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I-FARM: Farm of the Future

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Welcome to the USDA's only Farm of the Future!

About us

I-FARM stands for "Illinois Farming and Regenerative Management." This University of Illinois-led study — funded for three years and $3.9M by the U.S. Department of Agriculture's National Institute of Food and Agriculture (NIFA) — is developing an 80-acre agricultural testbed, where commodity crops, cover crops, and livestock are farmed using synergistic, sustainable practices.

The I-FARM testbed features improved precision farming with remote sensing; new autonomous solutions for cover-crop planting, variable-rate input applications, and mechanical weeding; and artificial intelligence-enabled remote sensing for animal health prediction, nutrient quantification, and soil health.

Videos from the field

Animals at IFARM

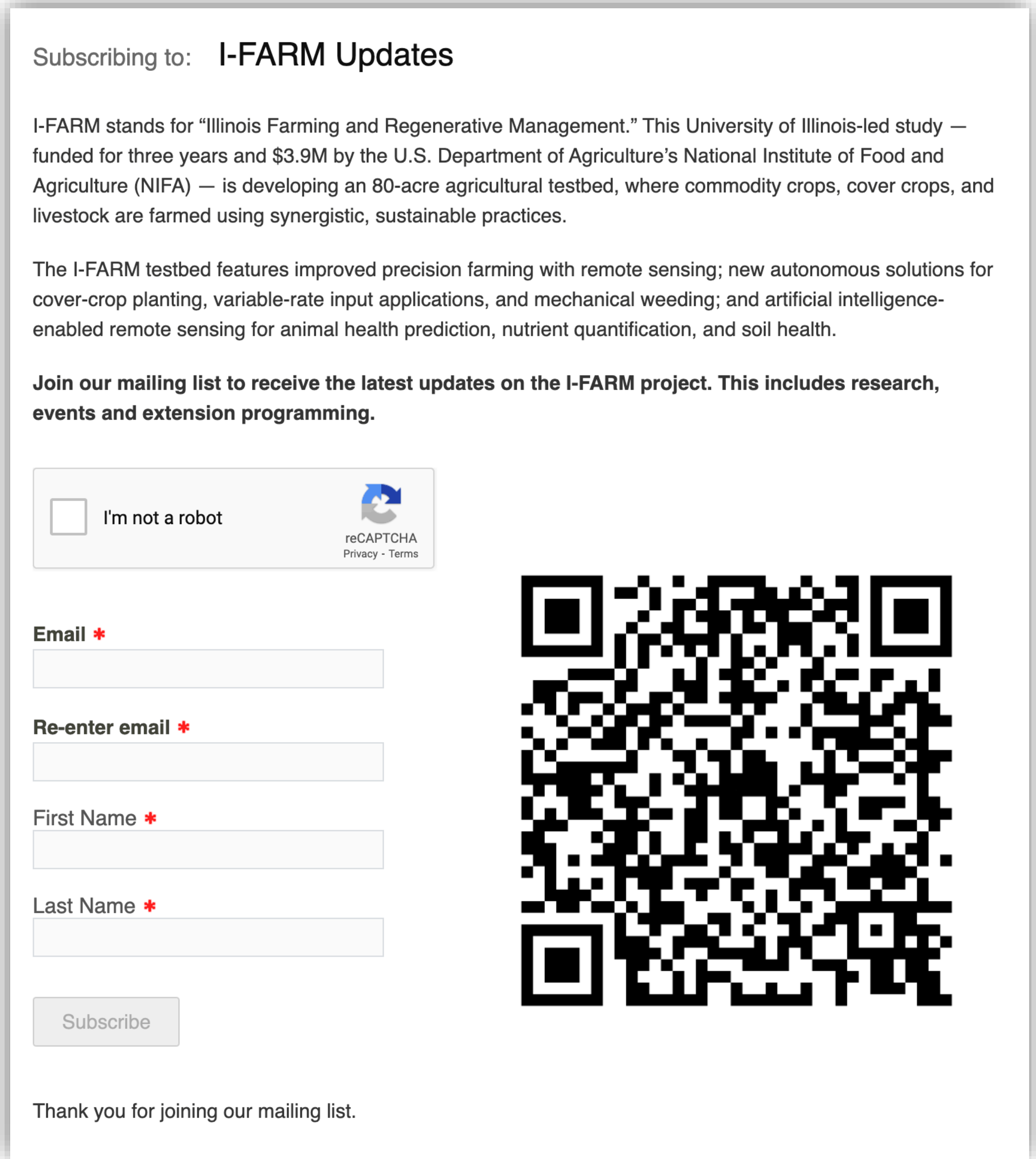
A full I-FARM video playlist may be found on YouTube >>>

I-FARM University: Passing on the knowledge!

I-FARM will demonstrate new technologies, data-driven products, and services for farmers and industry, easing adoption and opening new markets.

Robotics | Connectivity | Animals | Internet of Things

go.illinois.edu/ifarmupdates



Subscribing to: I-FARM Updates

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Join our mailing list to receive the latest updates on the I-FARM project. This includes research, events and extension programming.

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