Artificial Intelligence and Applications to Dryland Agriculture

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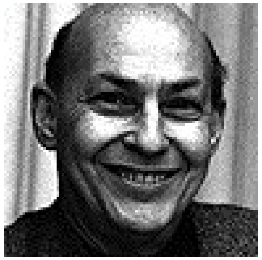
New Mexico State University

Overview of Presentation

- What is Artificial Intelligence?
- Why AI at NMSU?
- AI and Dryland Agriculture

What is Artificial Intelligence?

- The term “Artificial Intelligence” was coined in 1955 by John McCarthy
  - Study and development of computing systems that model and apply the intelligence of the human mind to solve problems [Minsky]
  - A branch of computer science dealing with the simulation/emulation of intelligent behavior in problem solving [McCarthy]
  - The capability of a machine to imitate intelligent human behavior
- The machine executes a program that demonstrates intelligent behavior

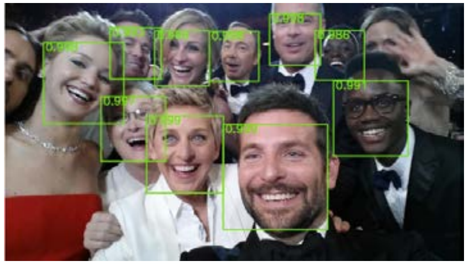


AI Landscape

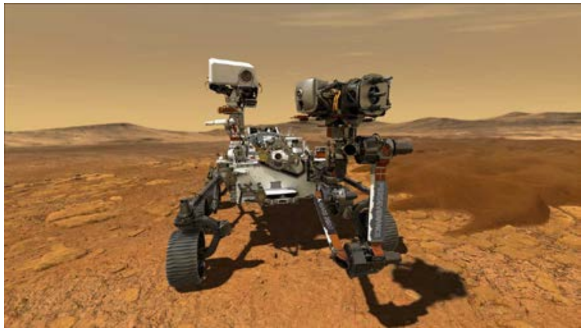
- Artificial Intelligence has been around since late 1950
- AI went through several "**Summers**" and "**Winters**"
  - 60s – connectionism, translation, automate theorem proving
  - Early 70s – first winter (ARPA, Lighthill report)
  - 80s – expert systems, Fifth Generation, planning
  - 90s – second winter (FGCS, DARPA)
  - Ongoing challenges – social ills, unemployment, end of humanity
- Today: Hot Summer
  - From **Clever** to **Stupid**
  - Data, data, data
  - Computing Power
  - Integration

AI in the Real World

- For the first time: AI in the hands of the general public
  - Siri/Cortana; Video Games; Voice Recognition
- Impressive success stories in selected domains

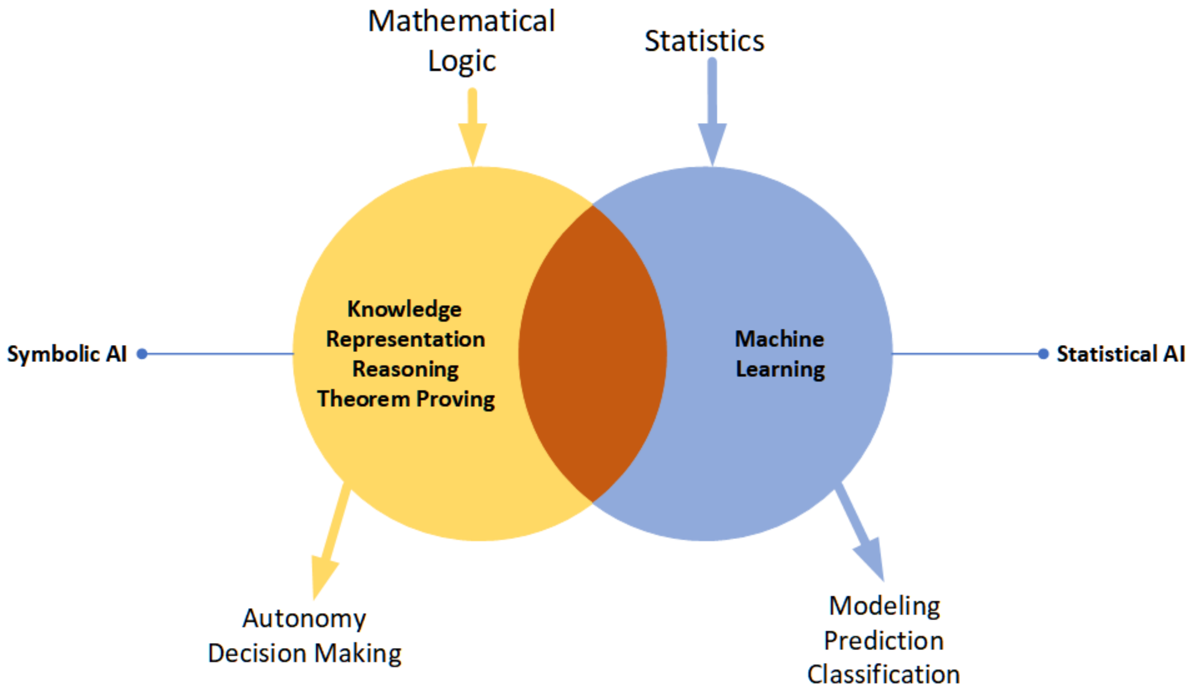




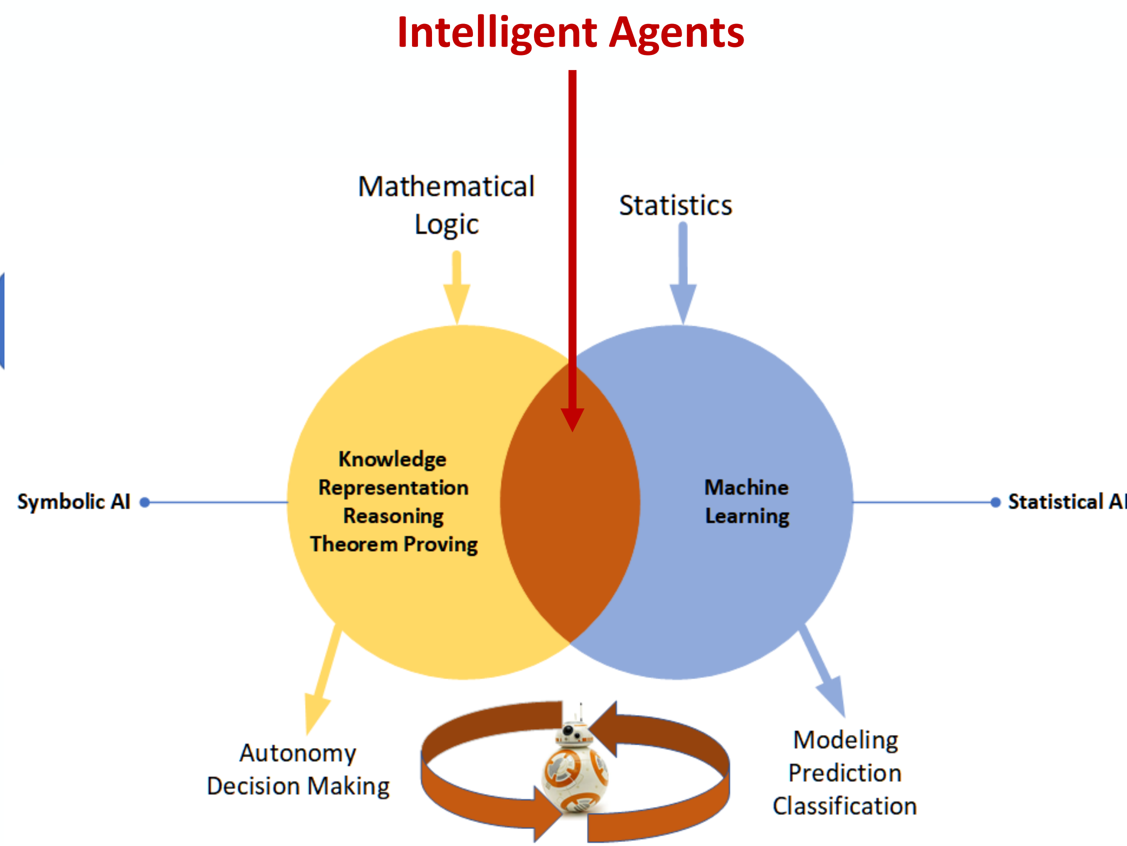

AI Today

- When today you hear AI:
  - **Machine Learning**
- Huge accumulation of **data**
- How to get from Data to **Knowledge**
  - Dependences/Predictions
  - Classification
  - Rules



AI Tomorrow


Data Collection, Curation, Reduction,....
Data Repositories


Intelligent Agents
Mathematical Logic
Statistics
Symbolic AI
Knowledge Representation Reasoning Theorem Proving
Machine Learning
Statistical AI
Autonomy Decision Making
Modeling Prediction Classification

AI Tomorrow (or already today…)

- Intelligent agents
  - An agent can be anything that **perceives** its environment, **thinks** about the environment and itself, and **acts** upon that environment through actuators
- Components of an Agent
  - **Knowledge** (about the world, about other agents, about itself)
  - **Reasoning** capabilities
    - Planning, Diagnosis, …
- Current Challenges
  - Explainability
  - Elaboration Tolerance
  - Performance and Scalability
  - Multi-agent systems (collaborative, competitive)
  - Epistemic reasoning (knowledge, beliefs, intentions, desires)

AI and New Mexico State University

- Computing Research Laboratory (1983)
  - Created with State funding as part of the Rio Grande Corridor
  - 12 full-time researchers and dozens of affiliated researchers
  - Ground-breaking research in areas like Natural Language Understanding, Automated translation, robotics, and vision.
- Computer Science Department
  - Long standing tradition of research in Symbolic AI and Autonomous Systems
  - 2011-2020: Top-50 US Institutions in AI [csrankings]
- Formal degrees
  - Formal concentration in AI in the CS undergraduate program
  - Master in Data Analytics
- Built talent pool
  - AI researchers in CS, A Stat, EE, ME, IE, Sociology, Mathematical Sciences
  - Effort to establish a broad AI & Data Science umbrella
- AI4All College Pathways
  - NMSU, UNT, Illinois Urbana-Champaign, Texas A&M

AI Innovations for Sustainable Agricultural Production in New Mexico

Drylands

Drylands are defined as regions with an aridity index ≤ 0.65

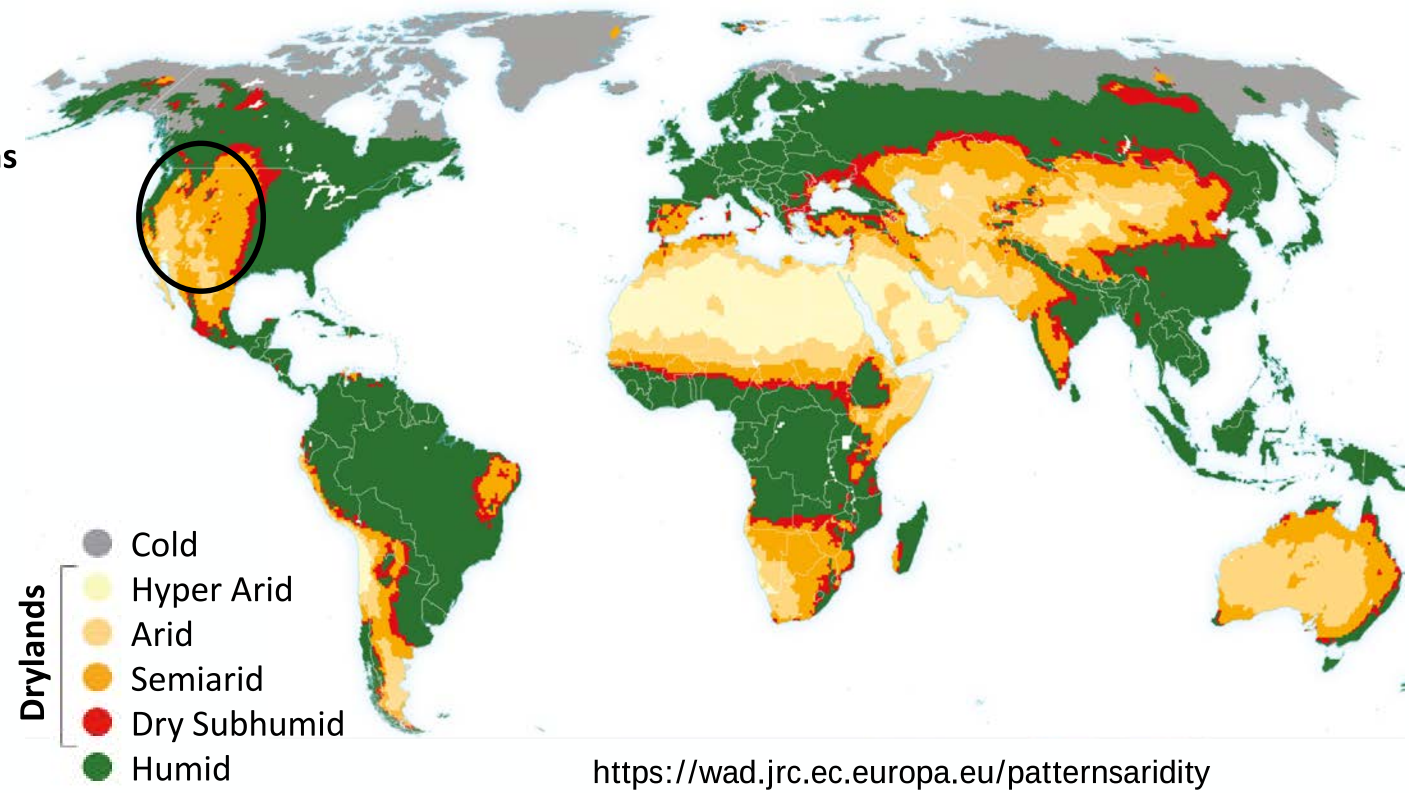
Aridity Index = $\frac{P}{PET}$ **where**

P = Precipitation

PET = Potential Evapotranspiration

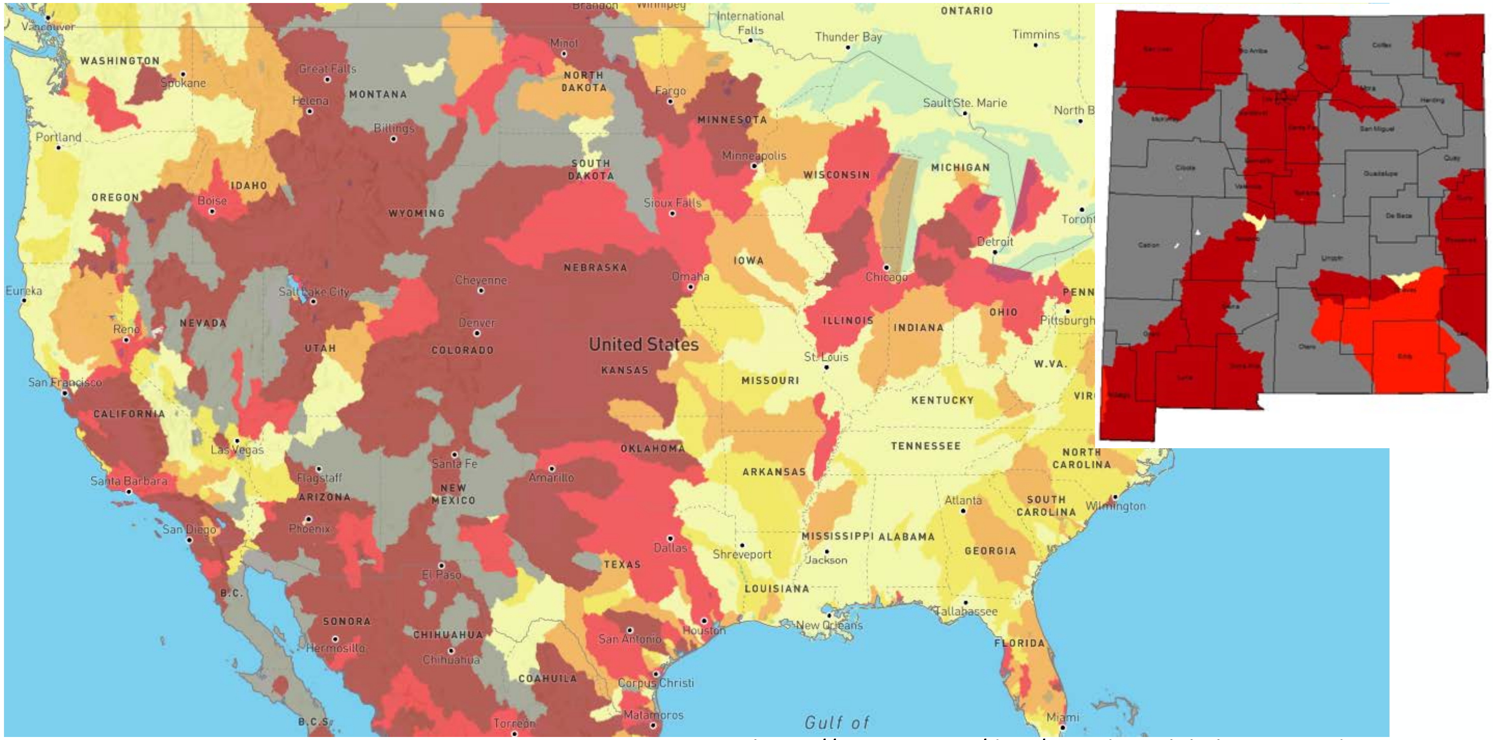
~50% of global land area

~40% of global population



https://wad.jrc.ec.europa.eu/patternsaridity

Increasing Water Stress



Projected Water Stress 2030

https://www.wri.org/data/aqueduct-global-maps-30-data

Low	Low to medium	Medium to high	High	Extremely high
(<10%)	(10-20%)	(20-40%)	(40-80%)	(>80%)

- Arid & low water use
- No data

Many areas in New Mexico will be under extremely high water stress by 2030

Agricultural Challenges in New Mexico's Drylands

How to be more productive with *less*

less arable land, *less* water, *less* labor, *less* certainty

- Cropping is more vulnerable because of low precipitation and reliance on scarce water for irrigation
- Livestock are more dispersed, and their well-being more difficult to monitor, because of the expansive pastures needed to support grazing
- Rangeland vegetation productivity and regrowth is more tenuous because of poor soils, frequent and prolonged drought and increased temperatures

To meet these challenges in New Mexico

Agriculture must be more:

Adaptable, to adjust to new, and increasingly variable conditions.

Resilient, to withstand disturbance such as weather and/or climate related stresses (e.g., drought) or market fluctuations.

Sustainable, to continue to meet current society's needs for food and fiber while preserving natural resources for future generations.

Field trial of clonal Pecan root stock

Agricultural systems are complex

- Interdependent
- Expansive
- Agency
- Tradition and culture
- Economics
- Nature

Tree Crops

Row Crops

Crop Production

Rangelands

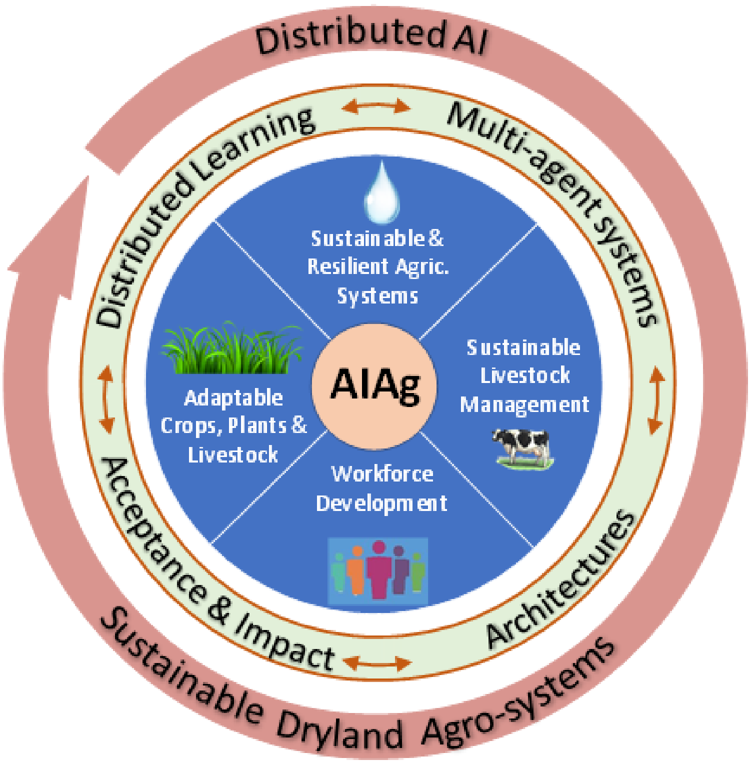
Livestock

Livestock Production

How AI can help Agriculture

- **Data collection:** Novel techniques that combine networked and autonomous smart sensors for data collection in rural areas with limited connectivity
- **Knowledge extraction:** Data-driven approaches to deal with massive quantities of heterogeneous information and advance detection, prediction, and evaluation
- **Model development and integration:** Required for prediction from diverse agricultural systems to holistically represent the social-environmental continuum
- **Smart decision making:** Transforming data, models and knowledge into adaptive decision support systems for end users (e.g., farmers, ranchers, land and water managers, policy makers)
- **Coordination and security:** Coordinating the diverse cyber-human-animal systems within the agricultural enterprise while preserving privacy

Harnessing AI for Agriculture in New Mexico



Example 1
Improved breeding

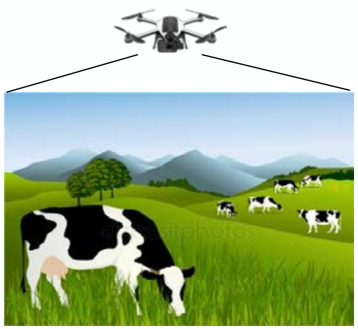
Increasing the **adaptability** of crops, rangeland plants and livestock to dryland conditions by identifying genotypes and phenotypes that thrive in highly variable and harsh environments and by accelerating regionally adapted breeding programs for specific traits through **knowledge extraction**

Pecan Rootstock Genetic Test System

Example 2
Precision Livestock Management

Increasing the **sustainability** of rangeland systems by remotely monitoring the condition of pastures and sensitive areas in near real-time and implementing management interventions to fully utilize pastures while preventing degradation through **knowledge extraction, model development, smart decision making**

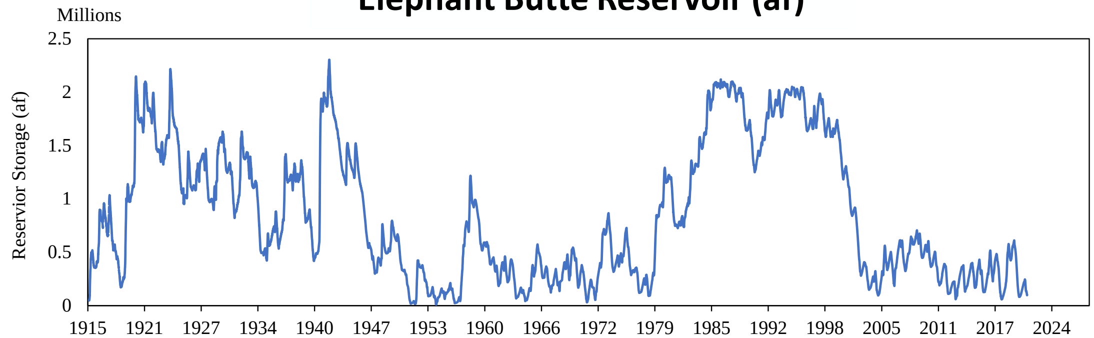
Increasing the **resiliency** and well-being of livestock by detecting changes in behavior associated with animal welfare concerns in real time and facilitating a rapid response through **data collection, knowledge extraction, smart decision making**



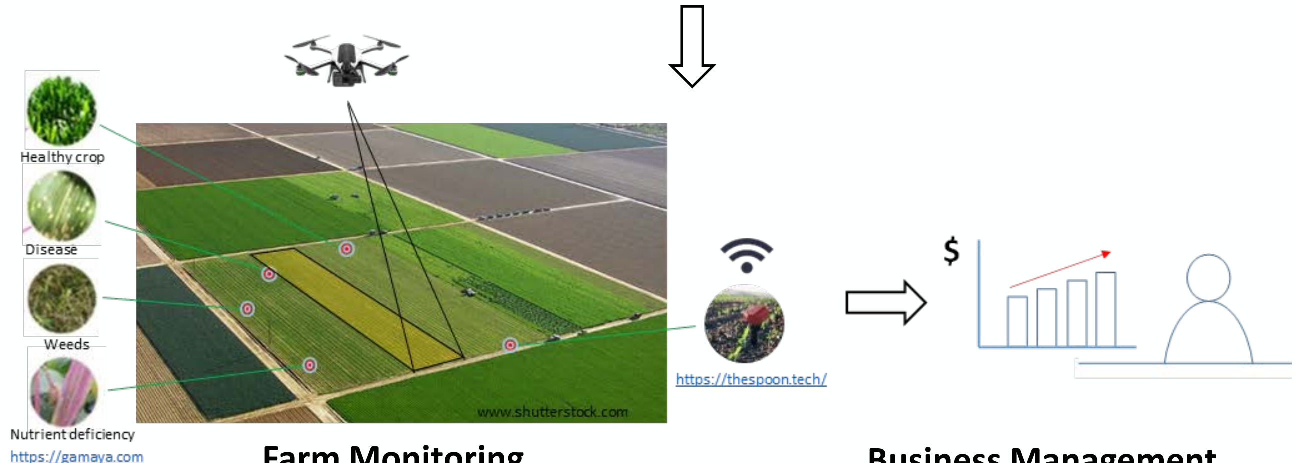
Example 3
Water and Crop Management

Increasing the **sustainability** of irrigated cropping systems by efficiently using the available water supply, maintaining or increasing crop yield, and minimizing environmental impacts through advanced crop monitoring and water use practices through **Model development and integration, Smart decision making, Coordination and security**

Elephant Butte Reservoir (af)



Streamflow and Reservoir Operations

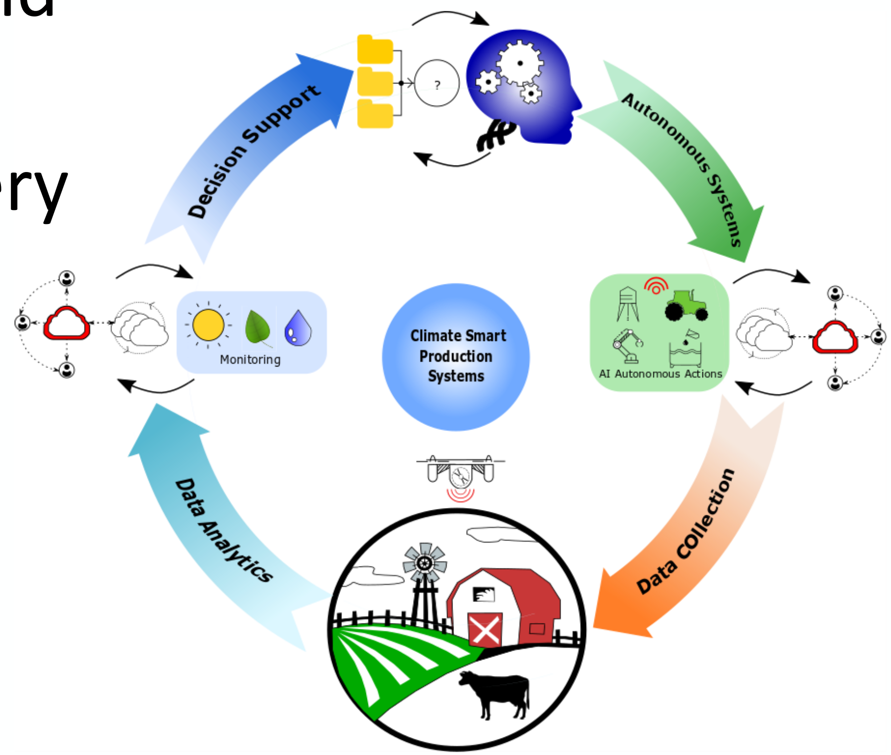


Farm Monitoring and Management

Business Management Decisions

Barriers to Adoption and Diffusion

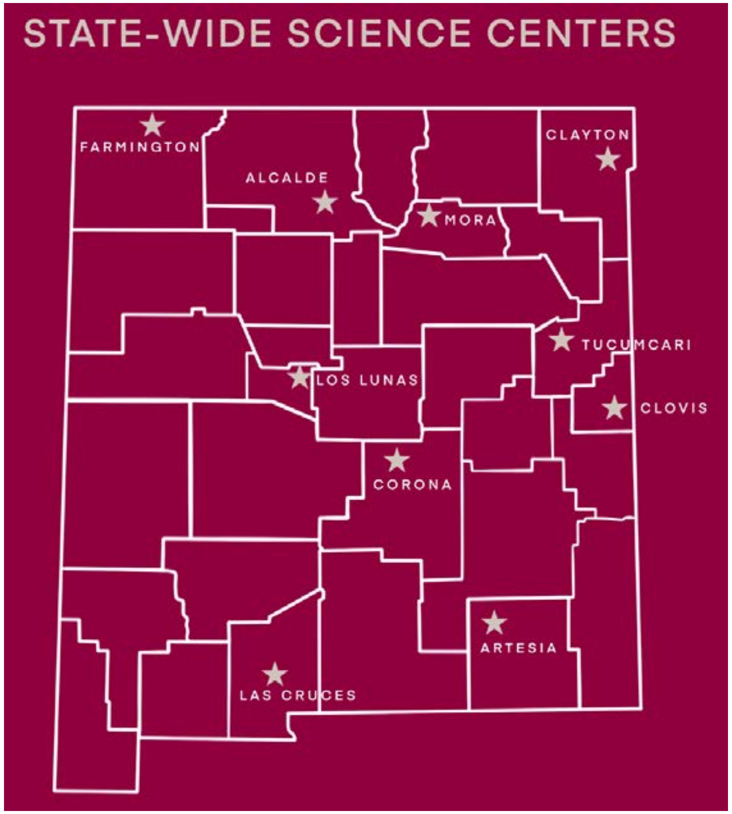
- Reliability of integrated AI and Ag systems
- Real-time information delivery
- Security of information
- Cost effectiveness
- Ease of use
- Education and training
- Social acceptance



Pathways for New Mexico to Adopt AI in Agriculture

Adopting AI in agriculture will help New Mexico to meet the challenge of providing a sustainable supply of food, water, and fiber

- Interdisciplinary research teams that span diverse disciplines to manage the technical, computational, environmental, economic and ethical dimensions of AI in agriculture
- Demonstration sites and collaborations with NM's stakeholders with hands-on AI and Digital Ag technologies to address local needs and seamless dissemination
- Education and training programs to meet the increased need and demand for a cross-disciplinary workforce



AI, Agriculture and New Mexico State University

Some examples of ongoing efforts at NMSU:

- Prediction of drought impacts using Machine Learning
- Training the next generation workforce for Food Science and Agricultural Technology in IoT
- Precision livestock management and animal health
- Irrigation management with wireless sensors networks
- High resolution satellite mapping of rangeland resources
- Data mining for accelerating improved genotypes and phenotypes

THANK YOU

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