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OFFICE OF THE VICE PRESIDENT --
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Before the Little Hoover Commission

Impacts of Artificial Intelligence in the Agricultural Sector

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Good morning Chair Nava and commission members; thank you for inviting me to speak before you today. Artificial intelligence (AI) is a critical issue in California agriculture and I am thrilled and honored to share with you what we do at the University of California and how the state government could be more involved to support the deployment and development of AI.

California continues to be the nation's top agricultural state. The University of California (UC) Agriculture and Natural Resources (ANR) is proud to be part of the Land Grant partnership that was developed between states and the federal government with the 1862 Morrill Act and subsequent legislation that created the Agricultural Experiment Stations and Cooperative Extension[1]. We have, for 150 years, advanced scientific knowledge in all aspects of food production and have improved capacity, profitability, and safety of the state's food system. Today, California's farmers produce half of the nation's nuts, fruits and vegetables and as a state we export food to countries around the world. In recent years, total agricultural production in terms of raw farmgate value has averaged almost $50 billion per year[2]. It is important to note that this value only includes the net value of the unprocessed product when it leaves the farm; for example, the value of grapes but not the wine it may ultimately produce.

The UC ANR Land Grant mission is delivered through several hundred academics conducting research on five campuses, nine Research and Extension Centers (RECS) and over 50 county offices throughout the state. Our RECS, located in different regions of California, serve as

[1] The Morrill Act, signed by President Abraham Lincoln in 1862, authorized "Land Grant" Universities. The Agricultural, Mining and Mechanical Arts College of California opened in 1868 in downtown Oakland. In 1873, it moved to its current location and became the University of California, Berkeley. In 1887, the Hatch Act authorized federal funding of Agricultural Experiment Stations. And in 1914, congress passed the Smith-Lever Act to form Cooperative Extension. As a result of the Smith-Lever Act, all states were to employ "county agents" whose salaries were paid by a joint agreement between federal and state governments. Local expenses were to be paid by the counties in which they worked.

[2] https://www.cdfa.ca.gov/statistics/

innovation hubs for both agriculture and natural resources. They have thousands of acres of research fields, specialized equipment, and expert scientists and staff who, for decades, have been growing and testing innovations and new technologies.

We work closely with a wide array of partners and volunteers to deliver programs ranging from 4-H Youth Development to Master Gardeners to Integrated Pest Management, and we manage the Nutrition Policy Institute and the Water Resources Institute for California. In the past fiscal year, UC ANR has served over 1.4 million adults and youth directly, published about 1,800 journal articles and filed over 20 patents[3]. Our 20,000 volunteers contributed the equivalent of over 700 FTE in public service – the equivalent of $40 million in donated time. 1,600 workshops and field days extended best practices and technologies resulting in increased yield, reduced inputs, improved economic return, and/or conservation of important natural resources.

Pertinent to this hearing are partnerships being formed as part of the Verde Innovation Network for Entrepreneurship (the VINE). This initiative was developed by UC ANR in 2016 to accelerate support for innovation and entrepreneurship in food, agriculture and natural resources. In 2017, UC ANR consulted key stakeholders across the state, hosted hackathons and camps, and sponsored events designed to catalyze regional collaborations of the statewide VINE. With a recent $500,000 grant won from the U.S. Economic Development Agency, UC ANR has assembled the VINE team, which includes the UC QB3 Institute and Sacramento-based AgStart. Other partners include the Western Growers Association Center for Innovation and Technology, CSU Fresno WET Center, West Hills College Farm of the Future, UC Merced VentureLab, and The Mixing Bowl Hub, to name but a few.

BACKGROUND

California's working landscapes face some critical challenges; among those are drought, climate change, air quality, soil health, pests, pathogens and invasive species. Additionally, rural/urban conflicts and urban sprawl continue to reduce available farm land and make viability of food production more difficult. Of importance to today's hearing, California's labor-intensive crops are facing increasing difficulty accessing necessary labor – both skilled and unskilled.

This situation has led growers and universities to seek solutions through mechanization, automation and other new technologies. Similar scientific advances have long been used to increase agricultural productivity; for example:

- Plant-breeding programs by Universities and the private sector have created crops that have higher yields, are more pest-resistant, easier to pick with harvesting machines, and are drought tolerant.
- Farm machinery of every kind has been used to aid in planting, harvesting and more, with increasing sophistication such as the increased use of GPS.
- Remote sensors to monitor weather, water and land have been used for years by researchers and increasingly by farmers.

"Precision Agriculture," is a term coined to describe how farmers can more precisely manage their fields by using site- and crop-specific data gathered by new technologies. A common example would be the use of remote sensors used to measure various crop health indicators

[3] http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=24839

such as soil moisture, temperature, and plant stress. Remote sensors can range from satellite imagery of an entire field to sensors placed directly on individual plant leaves. With this data, the farmer can see exactly what areas of the field need irrigation and what areas may be compromised by pests or disease, and take precise action. Of note, resolution of satellite imagery is rapidly improving as is informatics – the engineering of information systems and information processing.

Artificial intelligence (AI) improves this further by using the sensed environmental data to “learn” and continually adapt to ever-changing conditions as it receives data that strengthens the computer’s “intelligence.” The actions produced by AI might be to notify the farmer of crop updates via a smart phone, trigger a precise water or pesticide application, or guide the actions of harvesting equipment. Enhancing precision agriculture with AI has the potential to revolutionize agricultural production practices.

The availability of increasingly inexpensive cloud computing and data storage, coupled with low cost sensors and advanced robotics, will lead to rapid utilization of these agricultural technologies. For example, the “precision” in precision agriculture has dramatically increased with the availability of unmanned aerial vehicles (UAVs or “drones”) and the ability to use low cost, high quality cameras.

The addition of electronics and software to farm equipment, incorporating expertise from electrical engineering and computer science, is called “mechatronics” or “robotics”. Improving mechatronics is vital to solve problems such as harvesting delicate fruits and vegetables or doing precision weeding. As these robotics technologies continue to get less expensive and more closely mimic human actions, they will continue to get adopted in every facet of food production.

It is important to recognize that new equipment and technology can only go so far; the plants themselves must often be adapted to be handled by machines, and plant breeding for new varieties can take years, even decades. Altering this are new plant-breeding capabilities through rapid gene-editing using the UC Berkeley-discovered CRISPR/CAS9 technology may possibly change the entire plant breeding industry. We are close to the ability to rapidly edit genes and use precision phenotyping (studying the plant’s physical characteristics) to dramatically decrease the time it takes to create new plant varietals or change characteristics of a selected plant. However, agriculture must proceed cautiously here as the GMO debate surfaces when talking about gene-editing.

CHALLENGES

Despite the promise of agriculture technology, there are some key challenges that must be better understood and managed. Some issues will require additional investments in both infrastructure and research. Other matters may lead to the need for new business models. Among the key issues are:

- Artificial intelligence is extremely difficult in agriculture because of the huge amount of variability in environmental conditions across a single field. This requires many sensors, complex algorithms, and large real-time data processing – all integrated and working together to inform decisions and actions.

- The ability to pull together an array of data – from drones, robots, sensors, genomics – and use this for informed decision-making requires significant improvements in how we manage "big data." The challenges include:
  - Volume: data is coming at us from various devices – it's a lot and it's huge.
  - Variety: data can come from images, sensors, text and voices – it's all different and enabling interoperability can be expensive.
  - Velocity: data is coming in fast and constantly; it must be stored and processed very quickly to create any useful insights or decision points.
  - Veracity: ambiguous or imprecise data is an issue, as is keeping it current.
- There are many "point solutions" being developed by universities, startups, and corporate innovators, but not a lot of integration yet. Integration will be a key factor in making these technologies affordable and available to most farms, however few are working on this.
- Many startup technologies for AgTech are hitting the market with glossy websites, pitch events, and marketing materials that appeal to investors, but the science behind them is dubious. Growing food successfully requires many scientific disciplines; startups typically don't have strong farming backgrounds or knowledge of agronomy – especially across the diverse range of specialty crops that are grown in California.
- Startups are coming fast and furious at farmers, UC Cooperative Extension advisors, and agribusiness to the point they are overwhelming. They want products tested and "certified," if possible, to help make the sale against competing technologies. The question of "who pays?" for testing the efficacy of new technologies looms large for farmers and universities as well as the startups themselves.
- Increasingly the technology-driven solutions for agriculture coming from "Silicon Valley" – or the technology industry – are supported by venture capital. The culture and ways of operating among the tech and finance industry of Silicon Valley is very different than California's "food valleys" – which typically need more "patient capital" and longer timelines.

OPPORTUNITIES

Enhanced collaboration will be key to transformative innovation. We need to determine where government, industry, and academia can all work together to achieve meaningful outcomes. Furthermore, we must expand collaborative efforts between experts in soil science, plant pathology, biochemistry, entomology, and other fields of biological science with technology experts in robotics, sensors, artificial intelligence, materials, supply chain logistics, and energy systems to solve today's complex problems in agriculture. Much like the biomedical revolution, it is the integration of multiple disciplines into a single project that can lead to transformative innovation that improves productivity, food safety, and ecosystem services while also giving rise to new businesses. Examples of such multidisciplinary projects include:

- James Rogers studied flexible solar cells at UC Santa Barbara and Lawrence Berkeley National Laboratory. A radio program on world hunger gave the materials scientist his "aha!" moment in 2012. His work on thin-film polymers from solar cells, coupled with information from UC Cooperative Extension, led to an invisible, edible and tasteless barrier that can protect food crops and dramatically improve longevity of produce freshness – using waste plant parts often left on the farm. Apeel Sciences now supports 71 employees[4].

- The European Grapevine Moth (EGVM) was first detected in a Napa County in 2009, but quickly spread throughout the state, leading to quarantine restrictions. Quick collaboration between UC wine grape specialists, local agricultural officials, state and federal agencies, and vineyard operators, helped identify the problem and recommend a course of action leading to complete eradication. Solutions included mating disruption techniques, vector analysis and targeted insecticides to kill the insect. The last EGVM detection in California was June 2014[5].

- CropManage[6] is an UC ANR online database-driven tool that assists growers and farm managers in determining water and nitrogen fertilizer applications on a field-by-field basis. The software automates steps required to calculate irrigation and nitrogen fertilizer needs. The web application also helps growers track irrigation schedules and nitrogen fertilizer applications on multiple fields and allows users from the same farming operations to view and share data. Partners have included NASA and private sector firms.

In addition to the innovators and entrepreneurs coming out of the UC, CSU, and Silicon Valley, a key need is to train a next generation workforce of "advanced operators" who have integrated skillsets to fix and operate drones and robots, use technology tools to support their farm decisions, and operate complex farm machinery with new technology-enabled interfaces. Programs like West Hills College's Farm of the Future and Hartnell College's Innovation Farm are great examples of new programs that are emerging to address these challenges.

Technologies that use artificial intelligence are increasingly dependent on high-speed internet connectivity for real-time data uploads and processing in the cloud. If farms cannot get affordable broadband coverage, and/or bandwidth is limited, this will greatly hinder their ability to adopt new technologies. It's a challenge that industry, academia and the government must solve together. Fortunately, there is currently a great deal of support from state and federal interests to increase investments in rural broadband. The White House just released a report with recommendations to improve rural prosperity that puts a high priority on improving rural internet access[7]. California agencies and the private sector must find ways to leverage this.

Lastly, as I mentioned in my earlier comments, we are building a world-class innovation and entrepreneurship ecosystem in California for food, agriculture, natural resources and rural communities called the Verde Innovation Network for Entrepreneurship (the VINE). The VINE will help solve these challenges by creating a statewide community to connect and amplify our regional innovation hubs throughout California, support incubators, test and integrate technology such as robotics and artificial intelligence, integrate big data, and develop a funding strategy to support these innovations.

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[4] http://apeelsciences.com/

[5] Fitchette, Todd, "California eradicates the European grapevine moth", Western Farm Press, August 18, 2016, http://www.westernfarmpress.com/grapes/california-eradicates-european-grapevine-moth

[6] http://ucanr.edu/blogs/cropmanage/index.cfm?tagname=CropManage%203.0

[7] https://www.usda.gov/sites/default/files/documents/rural-prosperity-report.pdf

Currently, UC ANR is partnering with the California Department of Food and Agriculture to leverage the work of the VINE to accelerate development of a California Agricultural Technology Institute. The challenges we face – labor, water, climate, environmental compliance, and changing consumer preferences – threaten California agriculture's competitiveness on the world stage. Agricultural technology offers an opportunity to overcome these challenges; however, to commercialize and make them available in a timely manner, California needs a world-class innovation ecosystem that harnesses the power of collaboration and public-private partnerships.

With that Mr. Chair, I will wrap up my comments by reiterating that UC ANR is here to provide research, education, and public service to all Californians. This year, UC is celebrating its sesquicentennial. UC ANR is the original incubator and "tech support" for farmers and ranchers, bringing science and innovation to real-world problems for the past 150 years. We look forward to serving the people of California for the next 150 years as well.

Thank you for the opportunity to testify today. I am happy to answer questions you may have.