

**Artificial Intelligence and Machine Learning in Rural Tennessee Agriculture:  
A Workforce Study**

by

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## INTRODUCTION

The State of Tennessee is currently undergoing a period of rapid economic expansion and development (Boyd Center for Business and Economic Research, 2022). Businesses and industries are investing in Tennessee due to the favorable climate for start-up and growth with developed infrastructure and supply chains (Boyd Center for Business and Economic Research, 2022). Most of the expansion is in urban centers like Nashville, Knoxville, Chattanooga, Memphis, and Clarksville, Tennessee (Boyd Center for Business and Economic Research, 2022). An opportunity exists to expand into rural Tennessee with other economic opportunities outside of the traditional industry and business focus of urban growth. New markets related to supporting agriculture exist and are a possible source of new job markets and workforce training (Boyd Center for Business and Economic Research, 2022).

According to Tn. S.B. 2550/H.B. 2583, 2020, “agriculture is Tennessee’s largest industry, contributing approximately \$74.8 billion to Tennessee’s economy each year, employing 349,000 Tennesseans, and having diverse production ranging from row crops and livestock to local food and viniculture.” Tennessee recognizes that rural development is essential and necessary for continuing to build infrastructure and supply chains for existing and new businesses (Tn. S.B. 2550/H.B. 2583, 2020). As Tennessee’s population continues to migrate to urban hubs, support systems for rural populations and workforce development options are necessary for the sustainability of food production and supply chains.

## **The Economic Future of Agriculture**

According to Rolandi, Brunori, Bacco, and Scotti (2021), “rural communities suffer from several problems (difficulty in reaching markets, ageing, depopulation, lack of public and health services, etc.) that can also negatively affect sustainable food production.” The diminishing workforce for agriculture is a global phenomenon, and rural Tennessee data reflect the trend. According the most recent State of Tennessee economic outlook report produced in January of 2022, the aging workforce combined with the decrease in number of births will have a large effect on the economic success of Tennessee (Boyd Center for Business and Economic Research, 2022). The Boyd Center for Business and Economic Research (2022), states that the reduction in births will impact the labor market for agriculture, business, and industry. Furthermore, State of Tennessee data show that rural populations in traditional agriculture areas are declining as individuals move to urban areas for work (Boyd Center for Business and Economic Research, 2022).

Agriculture, historically, is a labor-intensive enterprise (Rolandi et al., 2021). The innovation of machinery to decrease the amount of human labor required for agriculture is only one aspect of strengthening food production and supply chains for a growing economy. Increasing yield in product is essential as is maximizing production on a diminishing supply of agricultural land (Tn. S.B. 2550/H.B. 2583, 2020). Data for the state of Tennessee from the Department of Agriculture provides evidence of a decline in the number of family-owned agricultural enterprises and a decline in land devoted to agriculture (Boyd Center for Business and Economic Research, 2022). The decline of agricultural land paired with a growing urban population indicates a possible need for

more modern farming methods that can increase yield on available land with less labor-intensive methods for growing and harvesting of food and other essential farming products.

Economic development trends in agriculture in Tennessee have focused, more recently, on re-building rural agricultural communities (Boyd Center for Business and Economic Research, 2022, p.18). The influx of State dollars to rural communities is to support placemaking, a practice for making smaller towns a destination and revitalizing their downtown areas to develop a vibrant lifestyle that attracts tourists and attracts or retains agricultural business owners and workers to remain in rural Tennessee (TNDECD, 2022). Essentially, these grants build small businesses that market niche agricultural enterprise products or cater to tourists and community needs. Examples of niche agricultural businesses or products are farm-to-table restaurants or hemp product stores from locally sourced products.

However, these placemaking activities are not the only opportunities for attracting and retaining a rural labor force. Exploration of emerging practices in agriculture evidence a growing field in artificial intelligence (AI) and machine learning (ML) (Zha, 2020). International and domestic trends indicate that the use of artificial intelligence and machine learning can increase agricultural yield and decrease the need for labor-intensive practices (Rolandi et al., 2021). The deployment of AI and ML in the State of Tennessee is an emerging practice that mimics the international and national trends (J. de Koff, personal communication, August 5, 2021). Research of trends in AI and ML indicate growth potential for drone operators, data workers, and educators related to deploying AI and ML full scale in rural communities (USDA-NIFA, 2021).

## **A Brief Overview of Artificial Intelligence and Machine Learning**

Artificial intelligence and machine learning should be defined, and a brief overview of their general applications should be provided as context. The term Artificial Intelligence or AI was first used by John McCarthy in 1956 in a lecture at Dartmouth College (Bini, 2018). McCarthy posited the idea of a sentient machine (Bini, 2018). According Poole, Mackworth and Goeble (1998), artificial intelligence is described as a device that is aware of its environment and take actions to change the environment for increasing their ability to meet a goal. A recognizable example would be Alexa, an artificially intelligent virtual assistant (Bini, 2018).

Machine learning (ML), is a sub-set of AI, according to Bini (2018). ML “learns from experience and improves its performance as it learns.” One of the promising applications of ML is efficiency (Bini, 2018). The ability to recognize and categorize visual data based on previous data and then use the new algorithm to improve that recognition for future applications means that the machine is learning (Bini, 2018). The software essentially makes choices and then better choices until it is accurate for recognizing what the software is being taught to recognize (Bini, 2018). Automatic tagging in Face Book photos based on facial recognition is an example of how ML has developed and been applied.

## **Artificial Intelligence and Machine Learning Trends in Agriculture**

The field of AI and ML in agriculture cannot be fully covered in a short capstone project, so the researcher will provide a high-level overview then focus on relevant trends as they relate to the potential to increase workforce opportunities in rural communities in

the State of Tennessee. Specifically, the applications of AI and ML will relate to increasing crop production and the gap in the labor force for agrarian laborers.

### **A National Push for AI and ML in Agriculture**

On July 29, 2021, the U.S. National Science Foundation (NSF) announced in conjunction with the U.S. Department of Agriculture’s National Institute of Food and Agriculture (USDA-NIFA) that they would invest \$220 million dollars in 11 new NSF-led Artificial Intelligence Research Institutes (USDA-NIFA, 2021). The partnership was created, “to pursue transformational advances in a range of economic sectors and science and engineering fields – from food system security to next-generation edge networks (USDA-NIFA, 2021). The program harnesses the accelerated collaborative transformational power of, “U.S. land-grant universities, farmers, producers, educators and innovators (USDA-NIFA, 2021).

Some AI Research institutes will work to innovate several sectors that will enable AI technology infrastructure and software development (USDA-NIFA, 2021). The USDA-NIFA Institute for Agricultural AI for Transforming the Workforce and Decision Support (AgAid) housed at Washington State University, is currently working to, “integrate AI methods into agriculture operations for prediction, decision support, and robotics-enabled agriculture (USDA-NIFA, 2021).” AgAid seeks to find solutions to challenges associated with labor, water, weather, and climate change (USDA-NIFA, 2021). AI training and education are also a focus of AgAid with the intent to build technological skills for an emerging tech savvy agricultural workforce (USDA-NIFA, 2021).

According to AgAid.org (2022), AgAid provides services for:

- Water intelligence,
- Farm intelligence,
- Labor intelligence,
- AI modeling and scaling for decision support
- Interactive human and AI workflows
- Workforce training
- Student research and internship opportunities

### **Solutions for a Declining Rural Population in Agriculture**

Zha (2020) provides a vision of robots equipped with AI and ML to fill the workforce gap created by the diminishing agricultural population. Automation, according to Zha (2020), is one solution for supplementing the labor market as populations decline. Automation of agricultural equipment with AI and ML can create machines that can make data-informed decisions. According to Rolandi et al. (2021), “Artificial Intelligence, for example elaborating data collected by in-field sensors, satellites, or drones about soil moisture, weather conditions, and plants status, can suggest cost-efficient use of resources (e.g., water, fertilizers, and pesticides), thus potentially increasing production, food quality, and farm incomes.” These digital assistants can create management structures that are less labor intensive and create less need for managers and operators on large farms (Rolandi et al., 2021).

### **AI and ML in Agricultural Equipment**

Exploration of the application of the AI technology as discussed by Rolandi et al. (2021) can be applied to machines like tractors, combines, and irrigation equipment to



reduce the time in the field for individuals in the agriculture industry. Future Acres, a developer of autonomous agriculture tools has developed Carry, a robotic harvest companion (Future Acres, 2022). Carry is designed to use computer vision and machine learning to be aware of its surroundings (Future Acres, 2022). Carry can transport 500 lbs of crops, stops for obstacles, can follow people, and is remote controllable (Future Acres, 2022). Carry is just one example of the technology being explored and developed to supplement the workforce.

### **Drones in Agriculture**

AI and ML are not relegated to just traditional agricultural equipment or sensors. Drones, a type of small unmanned flying devices that can be automated or piloted remotely, are now being used in new markets beyond military applications (Merkert & Bushell, 2020). Drones have the ability to leverage sensor technology and have the potential to impact agriculture practices in rural communities by decreasing workload for traditional agricultural tasks (Rolandi et al., 2021). Drones can use computer vision and machine learning as well. The researcher contacted and interviewed the Extension Program Leader-ANR for the Department of Agricultural and Environmental Sciences at Tennessee State University, Jason de Koff, Ph.D. In the interview conducted in fall of 2021, Dr. de Koff, also an Associate Professor of Agronomy and Soil Sciences discussed a fledgling outreach program he administers to introduce drone technology to agricultural communities in Tennessee. The program brings the technology to various co-ops and other rural gathering centers or events to begin interest for more in-depth training and use for Tennessee agricultural enterprises (J. de Koff, personal communication, August 5, 2021).

According to de Koff (2021) the drones currently being used in the program use video and image data that is captured then shared back to a device, like a mobile device or computer. The data is gathered as a Bluetooth or sometimes wireless connection, but sometimes, depending on the application and distance from the drone, the data is gathered later by plugging the drone in directly to the devices or computer (J. de Koff, personal communication, August 5, 2021). The device or computer then analyzes the data using algorithms developed for specific needs or purposes. The algorithms, according to de Koff (2021), use machine learning to increase their accuracy and provide recommendations for things like crop rotation or watering cycles.

The current applications of drones encompass tasks like identifying soil changes or pathogens that may be affecting large crop areas (J. de Koff, personal communication, August 5, 2021). Other uses include exploring hard to access fields or pastures to locate lost livestock (J. de Koff, personal communication, August 5, 2021). Dr. de Koff (2021) detailed a particular scenario in which facial recognition could be applied to livestock and tracking features enabled to essentially follow and monitor livestock. The drone has the ability to provide alerts that save time and wear and tear on vehicles that traditional practices would require (J. de Koff, personal communication, August 5, 2021).

### **Challenges and Solutions for AI in Tennessee Agriculture**

The excitement of using AI or ML in agriculture is tempered by existing infrastructure and policy challenges. Dr. de Koff (2021) provided an overview of the most pressing challenges for AI or ML use in rural Tennessee that includes the following issues:

- Access to urban and global markets

- Access to the internet in rural Tennessee
- Start-up cost of equipment
- Access to training for technology
- Laws and policies (specifically for drone use)
- Rural departure of potential workforce participants
- An aging agrarian workforce
- Inability to attract labor skilled in AI or ML use to rural communities

The data from the 2022 economic report by the Boyd Center for Business and Economic Research supports the assertions of Dr. de Koff that rural departure for urban centers is a verified phenomenon. Boyd Center for Business and Economic Research (2022) also details the existing issues with rural access to broadband internet that is necessary for modernizing agriculture in Tennessee. Dr. de Koff (2021) noted that his own outreach is limited because of insufficient funding and labor partners. The 2022 Boyd Center for Business and Economic Research report to Tennessee's governor and Tn. S.B. 2550/H.B. 2583 (2020) both recognize the economic need for Tennessee to focus on rural development and growth of the agricultural industry that will ensure a sustainable food source network for the future.

### **Tennessee Initiatives for Modernizing Rural Agriculture**

According to the 2022 Boyd Center for Business and Economic Research report (2022), the retirement cliff is approaching for the largest population of workers in the State of Tennessee. The rural agricultural centers will be no exception to a decrease in available workers. The impending retirement of the current agriculture workforce without sufficient next generation farmers has high potential to disrupt the food supply chain

(Boyd Center for Business and Economic Research, 2022). Dr. de Koff (2021) echoed the phenomenon in his interview.

### **Tennessee Seeks Solutions for Economic Growth in Agriculture**

Tn. S.B. 2550/H.B. 2583 (2020) is an attempt to circumvent the potential for disruption to the agriculture industry of Tennessee by creating opportunities in the agriculture industry in technology that could attract new workforce potential to the rural areas of Tennessee. Specifically, Tn. S.B. 2550/H.B. 2583 (2020) shares the vision of, “the opportunity to be the leading state in bringing together farmer-led innovation and entrepreneurship to create a diverse foundation of rural and agricultural enterprises and wealth creation.”

Two initiatives shared in the Tn. S.B. 2550/H.B. 2583 (2020), are the AgTech and AgLaunch365 grant programs. These programs are accelerator programs intended to create funding that develops new agriculture industries and techniques in Tennessee. AgLaunch began as a partnership between the Tennessee Department of Agriculture and the Memphis Bioworks Foundation (AgLaunch A, 2022). AgLaunch was, “designed to complement the efforts of Launch Tennessee – a statewide entrepreneurship organization (AgLaunch A, 2022).” The current AgLaunch initiative is a nonprofit that is a mix of public and private partnerships. Though these programs do contribute to agribusiness in Tennessee, they do not directly address the rural agriculture economy and declining rural population.

### **Outreach for Agribusiness Development and Modernization**

The location of the offices for AgLaunch and similar economic development initiatives within AgLaunch are typically centered in urban locations like Memphis, TN

(AgLaunch A, 2022). The portfolio of businesses created by AgLaunch are typically consultancy or data analysis driven (AgLaunch B, 2022). The location of the agribusiness start-ups create workforce opportunities in the urban communities like Memphis, Nashville, and Knoxville, TN. However, these urban focused agrarian initiatives with pilot sites do not provide a broad economic and workforce change for rural communities like the rural focused entrepreneurial initiatives of the Tennessee Main Street program. The Tennessee Main Street program is intended to create a more direct connection with community and local agricultural owners for entrepreneurial growth (TNECD, 2022).

Other rural outreach efforts are managed through the University of Tennessee Agriculture Extension offices. There are 95 UT Extension sites located within rural counties with a focus on local agribusiness support (UT Extension, 2022). The UT Extension offices provide, “research-based information about agriculture, family and consumer sciences, and resource development to the people of Tennessee where they live and work (UT Extension, 2022).” Dr. de Koff (2021) in noted??? that he typically works through UT Extension offices to provide information about using AI and ML with drones to enhance agricultural practices and business. Dr. de Koff (2021) shared that events often have low attendance and that the program had not yet developed a large demand. Barriers to attendance included difficulties of communicating with rural populations as well as an aging agriculture population that is distrustful of technology (J. de Koff, personal communication, August 5, 2021).

### **Possible Solution**

Rolandi et al. (2021), shared several factors that are contributing to a predicted decline in global rural agricultural economies. These same factors are substantiated by

The Boyd Center for Business and Economic Research (2022) and by Dr. Jason de Koff (2021). The factors are as follows:

- Access to urban and global markets
- Access to the internet in rural Tennessee
- Start-up cost of equipment
- Access to training for technology
- Laws and policies (specifically for drone use)
- Rural departure of potential workforce participants
- An aging agrarian workforce
- Inability to attract labor skilled in AI or ML use to rural communities

### **Strategic Planning for Economic Development in Rural Tennessee**

Strategic planning for economic development is the most essential tool for mitigating the barriers Tennessee rural agricultural communities are facing. The exploration of current initiatives related to rural agribusiness and technology indicate a diversified set of initiatives or tactics that seek to address the decline in rural populations and the relocation of the rural workforce to urban centers. The Governor’s Rural Task Force (2016) publication is the most recent evidence of a collaborative approach to address rural workforce departure.

The Governor’s Rural Task Force (2016) is a published plan for invigorating the rural communities of Tennessee. The plan provides a two-tiered approach of capacity building and placemaking. Capacity building is the ability of the community to leverage local resources for success (Tennessee State Government, 2016, p. 8). Placemaking is, “the planning and design of community places to promote overall wellbeing of an area

(Tennessee State Government, 2016, p. 8).” Together, capacity building and placemaking are the cornerstones of building an economy that is thriving and sustainable (Tennessee State Government, 2016, p. 8). Pillars for Community, Education, Wellbeing, and Job Creation are supported by programmatic initiatives in the plan with defined action steps or tactics associated with the programs listed with a completion year of 2022.

### **Strategic Planning as an Approach for Leveraging AI and ML**

The previous Tennessee Government plan for combating rural decline expires in 2022. An opportunity currently exists to engage in a focused statewide discussion with stakeholders about the success of the previous plan, and the lessons learned in the initiatives outlined in the plan. An opportunity also exists to build common focus across Tennessee for leveraging AI and ML as a rallying point for solving barriers in rural communities endangered by an aging workforce and rural departure. The previous plan included AI and ML as opportunities for agribusiness and workforce development, but the execution remained largely in urban centers with pilot connections to urban centers. The integration and application of AI and ML technologies in a modernized agricultural economy must move from the current urban centered tactics to a rural implementation model.

### **Creating a Draft Plan**

The following are a sample of ideas that might be in a strategic plan to implement AI and ML in rural Tennessee:

- Develop funding for new regional based AI and ML education programs that supplement traditional agriculture degree paths.

- Develop new training and certification programs related to AI and ML in emerging agricultural technology, like drones.
- Create and develop new types of agriculture technology staff positions at UT Extensions to bolster outreach provide training programs to rural communities.
- Create a strong infrastructure in rural areas for transportation and internet access that will attract new AI and ML start-ups in rural areas.
- Expand placemaking to include development that attracts remote workers from urban centers.
- Develop a robust strategic communication plan that engages P-16 partners and media to promote awareness of agribusiness career options in AI and ML.
- Develop AI and ML friendly laws and policies for Tennessee.

### **Conclusion**

AI and ML in agricultural business applications have the ability to modernize and transform Tennessee rural communities with new career paths that could decrease the labor migration from rural areas to urban centers. New agribusinesses in AI and ML machinery production for drones or automated robotics could support new career options for rural based training, implementation, and maintenance technicians. AI and ML technology applied to farming could increase the attractiveness of a rural career as a ‘modern’ farmer. Data produced as part of AI and ML applications from sensors could create higher yields with less labor and contribute to a national revolution in agriculture.



The 2022 expiration of the previous Governor's Rural Task Force (2016) plan affords an opportunity for the State of Tennessee to engage in a new economic development strategic planning process. Leaders and stakeholders should assess the effectiveness of the previous plan and begin developing a new strategic plan. In conclusion, the strategic planning process is an appropriate economic development tool for creating a statewide focus and support for AI and ML implementation as a tactic in rural agricultural areas that could increase rural labor population retention. A strategic plan could also launch a targeted communication and marketing plan to attract new types of work and workforce participants to rural areas for AI and ML based occupations and research. The researcher recommends that the State of Tennessee build better focus on AI and ML for rural communities to support food supply chain and to reduce rural labor participant migration to urban centers.

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