Hungarian Association of Agricultural Informatics
European Federation for Information Technology in Agriculture, Food and the Environment

Journal of Agricultural Informatics. Vol. 13, No. 1
journal.magisz.org

The Impact of Artificial Intelligence on Agricultural Labour in Europe

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Received
Accepted 08.03.2022
Available on-line 18.03.2022
Responsible Editor: L. Várallyai

Keywords:
AI, agriculture, labour, knowledge gaps

ABSTRACT

Artificial Intelligence (AI) is set to redefine how farming occurs. Throughout history examples of technological advances have shown that less labour has been required on a farm while at the same time increasing the output of food production. However, an interesting observation is that as technology has improved the farming process and replaced workers, it has opened a new avenue known as diversification. This paper focuses specifically on the impact that AI will have on the future of farming in the European sector. The literature brings to light common trends that technological innovations have always decreased the number of workers required in the farming process while at the same time maximising efficiency. AI will also follow the same trend, however, instead of eliminating workers in the farming process soon, the present observations show that farmers will still require workers to work alongside AI. The reason for increased investments in AI is due to research data showing a decline in population growth in Europe and the struggling profitability of farmers. Thereby analysts believe that a labour shortage will occur, and industries will struggle to fill those skills requirements. A qualitative summary was done on artificial intelligence technologies' development impact on the labour of the agricultural sector of Europe.

1. Introduction

Current literature and public media project the belief that technological development always replaces and reduces labour capacity in all sectors, particularly labour-intensive sectors such as agriculture (Klenert et al. 2020). Bessen (2016)'s review of AI's impact (as computer automation) on labour indicates, however, that the opposite has been true in the past. In general, AI technologies uptake has allowed for the creation of new and more sophisticated job opportunities in specific industries, which also allows for labour absorption from the oversupply in other industries, e.g., the I.T., financial, and logistics sectors (PWC 2018).

Specific industries such as agriculture, however, are more prone to experience a large decrease in labour due to AI technology uptake. As seen in the past 100 years with the increased mechanisation of farming, labour needs were drastically reduced and investment in further technological development sky-rocketed globally (Daly 1981, Christiaensen et al. 2020).

Employment in agriculture makes up less than 2% of national labour in the USA today, where it was as high as 40% in the early 1900s. During the same time, agricultural labour made up around 60% of the total labour force in Europe and dropped to 23% in 1970 (Grigg 1975). In 2010, it made up 5% of total formal employment in the EU-27. Up to 4.8 million agricultural jobs disappeared between 2000 and 2012 across the European Union (European Union 2013).

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Although employment in agriculture has decreased this past century, food production has significantly increased. Food being a basic human need and an essential economic good, its constant production has been vital. Food security has become an important policy focus for individual EU countries and the European Commission. This situation piques the interest of researchers to then understand what impact technological advancement has on the agricultural sector, and by extension, the labour force involved.

Oxford Economics (2019) projects that up to 2% of the general manufacturing labour force has been replaced by automation globally since 2000 and up to 10% of this labour can be replaced by 2030. In the agricultural sector in the EU, it is unknown what the effect of AI automation can mean for agricultural labour in the long term. The OECD defines AI as “A machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations or decisions influencing real or virtual environments” (OECD 2021). AI in this context includes programs, software, big data (predictive) analytics, cloud computing, and other computer automation.

Riding the waves of the digital revolution. It comes in the form of smart-phone assisted farm management (so-called “smart farming”) and harvesting, GPS-based tractor driving, autonomous machinery, drones with crop health sensing technology. These technologies have been designed to optimize and outperform natural processes, while based on these processes. It covers all management in agriculture from propagation, cultivation, livestock management, crop health, pest control, harvesting, crop yield and more.

This paper explores published literature on historical and current technological development replacing and reducing formal labour needs of the commercial agricultural sector in Europe and highlight knowledge gaps and future implications. The scope of this paper excludes consideration of part-time agricultural workers, such as family-run small-scale farm workers (landholders and family members) that make up 92% of this workforce (European Union 2013).

2. Historic Agricultural Development’s Impact on Labour

Welsh (2012) documents in her research that osteologists had discovered the genetics of early human beings located in Sweden and explains that these early people moved from southern to northern Europe to spread agriculture. When they first arrived in Europe, they learnt to clear forests for farming using the coppicing and pollarding method. Coppicing involved cutting a tree back to its base and then allowing it to produce multiple new stems; pollarding is the pruning of just the upper branches. It further revealed these people created hunter-gatherer communities. This meant hunters used flint-tipped tools for fishing and hunting deer. Then 3000 years later, archaeologists discover bones of domesticated animals, along with pottery containing remnants of grain. These findings point to a type of relationship between humans and nature where forests were cleared for farming space and moved on as space ran out. The employment of tools suggests that humans were the main source of input into agriculture (Spinny, 2020).

Of interesting fact is that between the years 1000 to 1300, Europe’s population witnessed exponential population growth with the advancement of medieval farming equipment such as the plough. The introduction meant efficiency and increased output to feed more people. The plough was a sharpened piece of wood that dragged behind a plough animal (Oxen) and would cut a space in the ground. Then seeds would be poured into the space and then covered with soil and watered. It is worth mentioning that this technology came from outside of Europe. Later, Eastern Europe adopted the use of a heavy plough which helped to aerate the soil and resulted in a higher return on crops. Higher yields meant that farmers increased and more farmland had come under cultivation. Farming spread from eastern Europe while also tapping into vast resources from northern Europe. The Romans first employed oxen to carry the plough but oxen were dumb and slow. Horses were used as an alternative as they are just as strong but intelligent but fast. This method of employing horses allowed farmers to cut the soil more effectively and cut more land than the oxen (Daileader, 2019).

(Daileader, 2019) further explains that the third technological advancement was the adoption of the watermill which was used to grind grains by harnessing the power of water. However, the Romans did not build too many watermills as they had hand mills. Hand mills required the use of a person to stand at the mill and turn the hand around. So why then would Romans not replace the hand mills with the watermills? The reason that many historians agree is that slaves were easily available and replaced. It made economic sense to simply buy more slaves as they wore out than to build a complicated watermill.

But as slavery faded out in Western Europe, watermills were built and by the 11 century, every river in Europe had a water mill. The grinding of grain which was once performed by humans was replaced by the windill. The additional labour was used in other ways, including clearing forests and bringing other lands under cultivation. The increases in food supply also boosted population growth from 5.5 million in 1700 to 9 million in 1801 (England). By 1900 this figure grew to 32 million (Boundless, 2018).

The industrial revolution saw a similar trend to the 1300s. This age was the dawn of machines and shifting away from hand manufacturing. The introduction of steam power and electricity gave rise to the factory system and mass manufacturing. But in this era, it is worth noting that humans were considered disposable and easily replaceable and were required to work under unsafe and dangerous conditions alongside machinery. Women and children were considered cheap labour that operated the machines in factories. The lack of autonomy and ethics of management meant that labour was still an important factor in production (Neal and Williamson, 2015).

An interesting phenomenon is how Europe was able to transform its food situation from a deficit to a surplus after World War 2. This is more funds were introduced to develop European infrastructure that was devastated by war. An increase in scientific activity as well as the movement to tractors on farms contributed towards efficient farming and led to the surplus. In Northern European countries, government interventions led to the successful restructuring of the countryside so that farming activities could resume (Martin, Pan-Montojo and Brassley, 2016).

3. Current AI development's impact on agricultural labour

Commercial agriculture in the EU is in a transition phase between large-scale mechanisation and AI-enhanced technologies. On the one hand, extensive mechanization of plant propagation, soil preparation, seeding, harvesting, and livestock management has profoundly impacted employment needs by decreasing labour requirements. On the other hand, AI-enhanced technologies have enhanced and optimized farming in the European context and have catalysed the need for a specialist workforce.

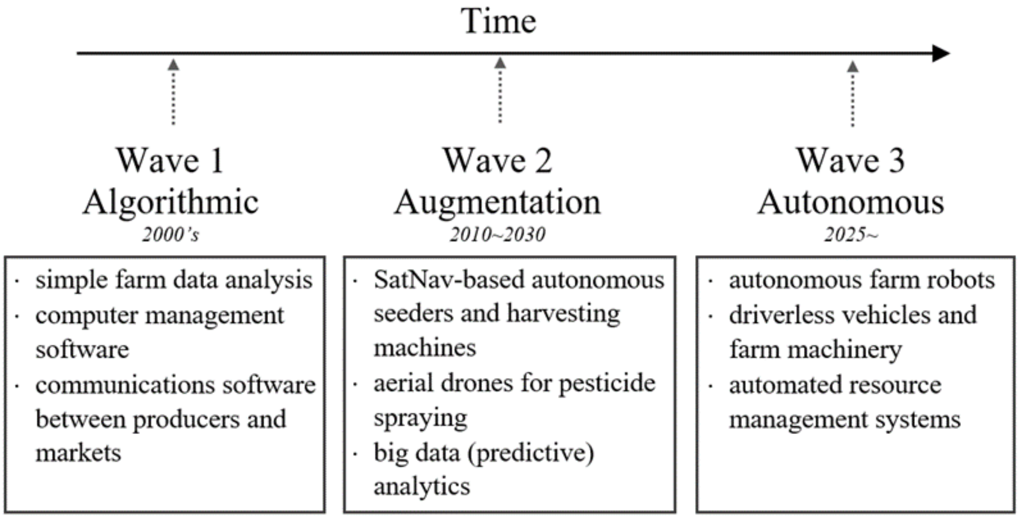
The number of people employed in agriculture to any degree in the EU in 2013 totalled 25 million people, calculating 9.8 million annual working units (AWU). Around only 14% or 3.5 million people, of this total amount, were employed full-time in agriculture (European Union 2013). This indicates that to a large degree, agricultural employment in the EU is mostly seasonal or part-time, with the labour force also involved in other industries' employment. Between 2013 and 2019, total EU agricultural labour input decreased by about 1 million AWU, to around 8.7 million (European Commission 2020). With grass- and crop-land covering 39% of land cover in the European Union in 2017 (around 1.7 million km2), agricultural technologies and machinery have significantly contributed to the EUR 341,098 million worth of agricultural goods output produced in 2019 (European Commission 2020, Pedroli and Meiner 2017).

Data for agricultural production are so numerous, it is now possible to standardise and enhance production protocols. Data is collected using various sources, such as soil sensors, automated irrigation systems, satellite-based imagery, local weather systems, etc. It provides actionable insights which help farmers make decisions to improve sustainability and efficiency and improve profitability. Predictive analytics of these data optimize the potential for healthy crop and livestock production and data-driven agriculture informs precision farming which substantially reduces costs and inputs, e.g., water and pesticide application and fuel costs.

PWC (2018) reported on the impact of automation on labour. This report summarises development waves of automation as (1) algorithm wave, (2) augmentation wave, and (3) autonomy wave. With increasing investment in new technologies, commercial farming has almost reached the third wave of autonomy. Since the 2000s, new computer software and hardware, running advanced programs and algorithms (the first wave), catalyzed the start of precision farming, with management that is based on real-time data, e.g., satellite imagery (NDVI mapping), soil sensors and probes, aerial drones, internet-connected irrigation management, etc.

Between 2010 and 2020, many agricultural machines have been retro-fitted or completely replaced with semi-autonomous computer-augmented pieces machinery (the second wave), such as self-driving tractors or colour-sorting machines for fruits and seeds. Autonomous robots overcome labour-heavy tasks on the farm and enable farmers to spend more time on aspects that improve efficiency (Eaton et al. 2008). The third wave of automation is projected to overtake the commercial agricultural sector within the next 20 to 50 years, with fully automated machinery, computerised food production management systems, and advanced precision farming based on cloud computing and installed sensors (Blackmore et al. 2005, King 2017).

The collection of data and data-based management has given rise to numerous new employment types, such as agri-consultants, specialised service providers and contract workers. These include workers that are highly skilled in plant production, plant protection, soil health, livestock, genetics, engineering, GIS, robotics, mechatronics, farm management, and business (Lane and Saint-Martin 2021).



Source: authors' deductions

Figure 1. The three PWC (2019) waves of AI in agriculture over time, with associated technology development for each wave.

As long as it is profitable, industries will continue developing and implementing new technological developments that increase the efficiency of the provisioning of goods and services. The incentives to further advance technology for agriculture is to improve food yields, decrease inputs, and improve management of risk in farming.

AI solves some challenges facing farmers as well. The general labour shortage for agriculture in the EU is caused by an ageing population, difficult working circumstances, competition by industries that provide more attractive job opportunities, and a lack of infrastructure for further development (Christiaensen et al. 2020). The contributing factor of increased minimum wage laws also makes it financially unjustifiable for farmers to employ a large worker force, it is more affordable over the long-term to use machinery (European Commission 2011). With an increase in living costs across Europe, the minimum wage is expected to increase over time which may mean that large-scale employment in agriculture may never be an option again for many European countries.

Other factors include low prices for agricultural products making it necessary for many farmers to work at full capacity with little wastage to ensure profitability, corporate companies producing a false demand for new agricultural machinery and products that companies spend a lot of money on in R&D, and the rise of AI technologies being integrated into many facets of life (i.e., the human dependency on internet and software), which increases demand for automated machines and drones.

4. Future Predictions

While it is expected that AI will impact and influence farming in ways known and unknown, below discusses a few ideas. First, the current trend with the adoption of AI will continue, then it can be expected that further cuts to labour will increase. Total agricultural employment in the EU decreased by 8% from 2012 to 2016. This is expected to further decrease by 28% between 2017 and 2030, to only 6.6 million people (European Commission 2017, p. 66).

Second, population growth in the EU is expected to decrease by 4%, or 20 million, from the present to the year 2100. The peak during this time is expected to be as soon as 2044. The implications this will have on EU policy and presently taking place is that more funds will be dedicated towards AI to make up for the shortage in labour. Third, the focus of AI will be increasing the output of food and the challenge will be efficiency in delivering food to the market. To achieve such efficiency, the European Commission (2019) outlines in the liability for Artificial Intelligence report that workers will work with AI and that guidelines on how much workers will rely on AI varies across industries.

In other words, the more that workers rely on AI the stronger hazards grow in the workplace and farmers need to accept liability for workers interests of safety. Fourth, in instances where workers are harmed by AI then workers should be able to claim compensation. Fifth, it guides the EU that precautionary steps that AI should continue to produce quality goods and services and manufacturers need to be held accountable for defects. Finally, it specifies that loss of data should be regarded as damage and should be fully compensated. This seeks to minimise the dangers to farmers and ensures they remain in business if they are injured or lose data. This helps to ensure they continue to supply the market with food.

There may come a time when farming or food production will not need to be done outside but will be produced inside automated facilities that fully control growth factors, i.e. the greenhouses used in the Netherlands where the oxygen is removed from the unit and completely replaced by carbon gas for faster growth (King 2017). Complete automation of farms/food production will only move over to full automation when it is more affordable to do so. This development may be useful to address food deserts in megacities (Tacoli, 2019). These are cities or local urban areas that are affected by global warming socio-economic challenges that cause limited access to affordable and nutritious food. As most of the world's populations will live in urban centres or “megacities” in the future, food and nutrition security will become an important policy focus for socio-economic development (Jowell, Zhou and Barry 2017; Maggio, Van Criekinge and Malingreau, 2017).

An emerging trend for the future is that as farmers rely more on AI, where new processes and suppliers will arise. Therefore, farmers will require the services of consultants who are experts in these new processes to help create an autonomous farm (Eastwood, Ayre, Nettle and Dela Rue, 2019). Since the EU population is expected to decline, then the rate at which AI replaces workers could be less severe.

AI will help in the sense of helping farmers make the best use of their limited resources to achieve food security. AI would also be used to connect farmers and buyers to ensure diversity of food and accurately match demand. Thus, ensuring there is no wasting and duplication of food. This will help towards achieving Sustainable Development Goal target 2.2 of eliminating all forms of malnutrition. The impact of the Covid19 pandemic on technology development is still largely unknown, however, since 2019, usage of the internet was 59.5% of the global community, where millions of internet-users either increase their usage or new users have entered the technological world (Hootsuite & We Are Social, 2019). By extension, more products and services are being sold online and businesses now have a strong incentive to pay for automated management and organisation systems to expand production capacity and supplies, particularly in the food production and service industries.

5. Knowledge gaps

Frank et al. (2019) summarise the barriers to the research of AI's impact on labour as a lack of high-quality data, empirical micro-level process models, and little understanding of the cognitive-economic-markets nexus' dynamics.

From the literature and trends reviewed, the following knowledge gaps have been identified which will inform how AI developments in agriculture will impact labour needs in the future and how society can prepare for it:

- Given the vast pace at which AI technology is being developed and its uptake in various sectors, is new work opportunities being created that can absorb displaced jobs or is government intervention required?
- If government intervention is required to curtail increased unemployment due to AI technologies replacing labour, which interventions would be best suited in general and for specific sectors?
- AI development puts the onus on countries' education and training curriculums to focus more on STEM subjects from primary, secondary to tertiary education. Or is alternative education and training for labour market absorption required?
- How can AI automation play a role in the affordability of foods in future, lower-income people purchase processed foods vs. higher-income buy more nutritious foods
- How will agricultural automation impact family-run farming businesses, when "traditional" farming becomes too expensive?
- Will AI enable flexible employment in the agricultural sector?
- Medium- to long-term consequences may involve further deurbanization of rural areas. Rural areas struggle to attract workers from outside the agricultural sector (European Commission 2017, p. 66)
- What will be the impact on employment polarization in the agricultural sector, where the middle- to low-level labour class is replaced by automation and AI technology?
- Autonomous farming may solve the issue of agricultural land shortage, agricultural extensification and expansion into natural environments has caused major detrimental impacts to nature and people.
- Big data (predictive analyses) already plays a central role in identifying oncoming environmental disasters, such as droughts, floods, and insect swarms. In the future, will it play a more central role in mitigating crop loss due to these disasters?
- Automation and AI used in the biotechnology sector could provide alternative approaches to food production that is more ethical in terms of animal care and preservation of natural ecosystems and their functions.
- How can smart farming play a role in making supply vs. demand market dynamics more efficient to decrease food wastage?
- People will have more time to develop talents. Challenge in bridging the gap between low skill labour to high skill labour.

6. Conclusion

In the present phase of AI automation, it won't fully replace labour but will occur at an increasing rate. However, when the next AI wave approaches soon, more robots and autonomous machines will replace labour and the majority of labour used on farms will maintain robots and automation and implement and apply decisions based on big data (predictive) analytics in agricultural contexts. In the long-term, we predict that farming and food production will be fully automated, with little (or highly specialized) human involvement in cultivation, production, harvesting and processing. The European Union has made the move towards AI to remain relevant and competitive in the global market. Preemptive moves such as the investment of funds have been taken in response to shrinking European populations and an ageing population. Also, the increasing minimum wage would make it expensive for farmers to employ workers in the long run. Another consideration for the move towards AI has increased production efficiency which AI can achieve to decrease inputs and prevent food wastage. Autonomous farms will require farmers to develop new skills and also increase usage of management farming tools. Many knowledge gaps were uncovered, perhaps the most crucial question to be researched is how will workers that have been replaced by AI be absorbed in other industries and what exactly will farm labourers do now that they have time to develop other competencies? AI will also address the issue of sustainable economies and open the way for the preservation of natural ecosystems that were destroyed by overconsumption of natural resources.

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