# AI4Agri

## Developing green and digital skills towards AI use in agriculture

Erasmus+

KA220-VET - Cooperation partnerships in vocational education and training

## WP2: Connecting AI with Agricultural sector: current status and needs assessment

## A.2.4: Delivery of Final AI4Agri Analysis

Developed by

OMNIA

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AI4AGRI

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# EXECUTIVE SUMMARY

This report, deliverable A2.4, "Delivery of Final AI4Agri Analysis'', was prepared as part of the co-funded European Erasmus+ Program, entitled "Developing green and digital skills towards AI use in agriculture'' and acronym AI4Agri. It's part of the deliverables of WP2," Connecting AI with Agricultural sector: current status and needs assessment ".

The AI4Agri project created in order to develop new digital and green skills for a greener and digitalised labour market in the agriculture industry. The current final analysis report acts as a first step to achieve that purpose and has been developed to 1) analyse the current EU and national policies and regulations related to agriculture and AI, 2) discuss how AI technologies are being adapted and implemented in the four participating countries, Poland, Sweden, Cyprus and Greece 3) provide a comprehensive overview of AI technologies, methods, and tools currently employed in agriculture, 4) identify and record the available pedagogical approaches and training programs related to addressing the digital literacy gap among agriculture workers, 5) identify best practices and successful training initiatives in the four countries, 6) identify gaps and needs of agricultural workers and potential entrepreneurs in learning and adopting AI uses in agriculture.

Specifically, desk research had been conducted to provide an overview of AI uses in agriculture, best practices, available pedagogical approaches and training programs (so as to fulfil the 5 aims mentioned above). On the other hand, surveys and roundtables had been conducted to fulfil the aim of identifying agriculture workers and entrepreneurs' AI-related knowledge, needs, skill gaps (to fulfil the 6$^{th}$ aim mentioned above). This is crucial since the development of the current report will assist in the development of the respective training needs of WP4, which are the AI4Agri curriculum and training.

The European Union (EU) has a comprehensive set of agriculture regulations in order to guarantee a steady supply of food, secure farmers' income, and preserve the environment. These policies are constantly evolving to address new challenges and opportunities, and they increasingly recognize the potential technology to transform the agricultural sector. The Common Agricultural Policy (CAP) is the cornerstone of EU agriculture policy and has a cross-cutting objective on digitisation, knowledge and innovation. The European Green Deal and the current EU agricultural policies are closely correlated as they both aim to promote sustainability and resilience, also within the agricultural sector. The European Green Deal addresses climate neutrality, biodiversity conservation, circular economy, sustainable food systems and digitalisation and innovation.

The vast possibilities offered by AI, ranging from precision agriculture, livestock management optimization, supply chain innovation to predictive analytics and autonomous machinery, AI is revolutionizing traditional farming methods, empowering farmers with advanced tools and insights and hold immense promise for enhancing agricultural productivity, efficiency, and sustainability, shaping the future of food production and global food security.

Nevertheless, in most countries throughout Europe, they are still exploring the transformative potential of AI and other digital technologies within its agricultural sector, even though it is rapidly developing during the last few years.

The review and analysis on AI, agriculture technology and farmer-driven innovations and best-practices on the field in the four countries showed the following: AI in precision farming is revolutionizing agriculture in Poland. With a rich agricultural heritage and a commitment to embracing technological advancements, Poland is leveraging AI to address key challenges and unlock opportunities within its agricultural landscape. Sweden wants to become a global leader within innovation and the use of digital solutions and one of the technologies to achieve this goal is AI.  In Sweden, the use of AI in agriculture is growing rapidly, as farmers seek to improve productivity and sustainability. In Cyprus, although in the last years has introduced several initiatives to boost the agricultural sector still, agriculture practices are more 'traditional' with a limited implementation of 'smart' practices. In Greece, the emergence of AI in agriculture is worth noting, with the nation's digital strategy aiming to integrate AI across diverse agricultural practices and the several pedagogical approaches and training programs from universities and funded programs that are being implemented to address the digital literacy gap among agriculture workers.

However, the survey carried out in the four countries revealed that all four countries lack in a wide range of knowledge on the subject.

In Poland, they have an average knowledge of the main adaptive factors of the technology use in agriculture. In Sweden they have the highest level of awareness about AI, but this is not associated with hand-on experience in AI applications. They also seem to be aware of the environmental benefits of AI use in agriculture and the efficient improvement and productivity in agricultural practices. On the contrary in the rest of the countries, only half of the participants seem to be aware of the above-mentioned benefits. In Cyprus there is a very low level of knowledge and implementation of AI use in agriculture. Similar, in Greece, most of the workforce either are vaguely familiar or not familiar at all with such concepts, there is a small number that is working with AI technologies but in general, there is lack of knowledge.

Finally, both the survey and roundtable findings revealed a significant skill gap among agricultural workers and entrepreneurs. There is a need for raising awareness on the digitalisation of agriculture, the contribution of AI in sustainable development and green decision making. There is also a clear need for customized training programs that focus on practical applications of AI in agriculture.

Both agricultural workers and entrepreneurs should be trained on (1) basic digital skills, to have a general overview and understanding how to use digital tools and platforms so to know how to use the AI tools of the different applications (2) data analysis, understanding how to interpret and use data can help improve decision-making and increase productivity, (3) soft skills such as communication and problem solving and (4) green skills and sustainable practices to develop a common understanding.

# PODSUMOWANIE

Niniejszy raport stanowi rezultat A2.4 „Dostarczenie końcowej analizy AI4Agri" i został przygotowany w ramach współfinansowanego europejskiego programu Erasmus+ zatytułowanego „Rozwijanie umiejętności ekologicznych i cyfrowych w kierunku wykorzystania sztucznej inteligencji w rolnictwie" o akronimie AI4Agri. Jest to część rezultatów WP2, „Łączenie sztucznej inteligencji z sektorem rolnym: stan obecny i ocena potrzeb".

Projekt AI4Agri został stworzony w celu rozwijania nowych umiejętności cyfrowych i ekologicznych dla bardziej ekologicznego i ucyfrowionego rynku pracy w branży rolniczej. Obecny raport z analizy końcowej stanowi pierwszy krok do osiągnięcia tego zamierzenia i został opracowany w celu 1) przeanalizowania aktualnych unijnych i krajowych polityk i przepisów związanych z rolnictwem i sztuczną inteligencją, 2) omówienia sposobu adaptacji i wdrażania technologii sztucznej inteligencji w czterech uczestniczących krajach, Polsce, Szwecji, Cyprze i Grecji, 3) zapewnienia kompleksowego przeglądu technologii, metod i narzędzi sztucznej inteligencji stosowanych obecnie w rolnictwie, 4) zapewnienia kompleksowego przeglądu technologii, metod i narzędzi sztucznej inteligencji stosowanych obecnie w rolnictwie, i narzędzi stosowanych obecnie w rolnictwie, 4) zidentyfikowania i zarejestrowania dostępnych podejść pedagogicznych i programów szkoleniowych związanych z radzeniem sobie z luką w umiejętnościach cyfrowych wśród pracowników rolnictwa, 5) zidentyfikowania najlepszych praktyk i udanych inicjatyw szkoleniowych w czterech krajach, 6) zidentyfikowania luk i potrzeb pracowników rolnictwa i potencjalnych przedsiębiorców w zakresie uczenia się i przyjmowania zastosowań sztucznej inteligencji w rolnictwie.

Dokładniej, przeprowadzono badania źródeł wtórnych, aby zapewnić przegląd zastosowań sztucznej inteligencji w rolnictwie, najlepszych praktyk, dostępnych podejść pedagogicznych i programów szkoleniowych (aby zrealizować 5 celów wymienionych powyżej). Z drugiej strony przeprowadzono ankiety i okrągłe stoły w celu zidentyfikowania wiedzy, potrzeb i luk w umiejętnościach pracowników rolnictwa i przedsiębiorców związanych ze sztuczną inteligencją (aby spełnić szósty cel wspomniany powyżej). Ma to kluczowe znaczenie, ponieważ opracowanie obecnego raportu pomoże w opracowaniu odpowiednich potrzeb szkoleniowych WP4, którymi są program nauczania i szkolenia AI4Agri.

Unia Europejska (UE) posiada kompleksowy zestaw przepisów dotyczących rolnictwa w celu zagwarantowania stałych dostaw żywności, zabezpieczenia dochodów rolników i ochrony środowiska. Polityki te stale ewoluują, aby sprostać nowym wyzwaniom i możliwościom, i coraz częściej dostrzegają potencjał technologii w zakresie transformacji sektora rolnego. Wspólna Polityka Rolna (WPR) jest kamieniem milowym polityki rolnej UE i ma przekrojowy cel dotyczący cyfryzacji, wiedzy i innowacji. Europejski Zielony Ład i obecna polityka rolna UE są ze sobą ściśle powiązane, ponieważ oba mają na celu promowanie zrównoważonego rozwoju i odporności, również w sektorze rolnym. Europejski Zielony Ład dotyczy neutralności klimatycznej, ochrony różnorodności biologicznej, gospodarki o obiegu zamkniętym, zrównoważonych systemów żywnościowych oraz cyfryzacji i innowacji.

Ogromne możliwości oferowane przez sztuczną inteligencję, począwszy od rolnictwa precyzyjnego, optymalizacji zarządzania inwentarzem żywym, innowacji w łańcuchu dostaw, po analitykę predykcyjną i autonomiczne maszyny, rewolucjonizują tradycyjne metody uprawy roli, zapewniając rolnikom zaawansowane narzędzia i wgląd, a także niosą ze sobą ogromną obietnicę zwiększenia

produktywności, wydajności i zrównoważonego rozwoju rolnictwa, kształtując przyszłość produkcji żywności i globalnego bezpieczeństwa żywnościowego.
Niemniej jednak, w większości krajów w Europie wciąż bada się potencjał transformacyjny sztucznej inteligencji i innych technologii cyfrowych w sektorze rolnym, mimo że w ciągu ostatnich kilku lat szybko się on rozwijał.

Przegląd i analiza sztucznej inteligencji, technologii rolniczych i innowacji napędzanych przez rolników oraz najlepszych praktyk w terenie w czterech krajach wykazały, że sztuczna inteligencja w rolnictwie precyzyjnym rewolucjonizuje rolnictwo w Polsce. Dzięki bogatemu dziedzictwu rolniczemu i zaangażowaniu w postęp technologiczny, Polska wykorzystuje sztuczną inteligencję, aby sprostać kluczowym wyzwaniom i odblokować możliwości w swoim krajobrazie rolniczym. Szwecja chce stać się światowym liderem w zakresie innowacji i wykorzystania rozwiązań cyfrowych, a jedną z technologii służących osiągnięciu tego celu jest sztuczna inteligencja. W Szwecji wykorzystanie sztucznej inteligencji w rolnictwie szybko rośnie, ponieważ rolnicy dążą do poprawy wydajności i zrównoważonego rozwoju. Na Cyprze, chociaż w ostatnich latach wprowadzono kilka inicjatyw mających na celu pobudzenie sektora rolnego, praktyki rolnicze są bardziej „tradycyjne” z ograniczonym wdrażaniem „inteligentnych” praktyk. W Grecji warto odnotować pojawienie się sztucznej inteligencji w rolnictwie, wraz z krajową strategią cyfrową mającą na celu integrację sztucznej inteligencji w różnych praktykach rolniczych oraz kilkoma podejściami pedagogicznymi i programami szkoleniowymi z uniwersytetów i programów finansowanych, które są wdrażane w celu wyeliminowania luki w umiejętnościach cyfrowych wśród pracowników rolnictwa.

Jednak badanie przeprowadzone w czterech krajach wykazało, że we wszystkich czterech krajach brakuje szerokiego zakresu wiedzy na ten temat.

W Polsce mają oni przeciętną wiedzę na temat głównych czynników adaptacyjnych wykorzystania technologii w rolnictwie. W Szwecji mają najwyższy poziom świadomości na temat AI, ale nie jest to związane z praktycznym doświadczeniem w zastosowaniach AI. Wydaje się również, że są świadomi korzyści środowiskowych wynikających z zastosowania sztucznej inteligencji w rolnictwie oraz skutecznej poprawy i wydajności praktyk rolniczych. Natomiast w pozostałych krajach tylko połowa uczestników wydaje się być świadoma wyżej wymienionych korzyści. Na Cyprze istnieje bardzo niski poziom wiedzy i wdrażania sztucznej inteligencji w rolnictwie. Podobnie w Grecji, większość pracowników albo jest słabo zaznajomiona z takimi koncepcjami, albo w ogóle ich nie zna, istnieje niewielka liczba, która pracuje z technologiami sztucznej inteligencji, ale ogólnie brakuje wiedzy.

Wreszcie, zarówno wyniki ankiety, jak i ustalenia okrągłego stołu ujawniły znaczną lukę w umiejętnościach wśród pracowników i przedsiębiorców rolnych. Istnieje potrzeba podnoszenia świadomości na temat cyfryzacji rolnictwa, wkładu sztucznej inteligencji w zrównoważony rozwój i ekologicznego podejmowania decyzji. Istnieje również wyraźne zapotrzebowanie na spersonalizowane programy szkoleniowe, które koncentrują się na praktycznych zastosowaniach sztucznej inteligencji w rolnictwie.

Zarówno pracownicy rolni, jak i przedsiębiorcy powinni zostać przeszkoleni w zakresie (1) podstawowych umiejętności cyfrowych, aby uzyskać ogólny przegląd i zrozumienie, jak korzystać z narzędzi i platform cyfrowych, aby wiedzieć, jak korzystać z narzędzi AI w różnych aplikacjach (2) analizy danych, zrozumienia, w jaki sposób interpretacja i wykorzystanie danych może pomóc w poprawie procesu podejmowania decyzji i zwiększeniu wydajności, (3) umiejętności miękkich, takich jak komunikacja i rozwiązywanie problemów oraz (4) umiejętności ekologicznych i zrównoważonych praktyk w celu wypracowania wspólnego zrozumienia.

# SAMMANFATTNING

Denna rapport, leverans A2.4, ”Leverans av slutlig AI4Agri-analys”, utarbetades som en del av det samfinansierade europeiska Erasmus+ programmet, med titeln ”Utveckla gröna och digitala färdigheter för AI-användning inom jordbruket” och akronymen AI4Agri. Den är en del av leveranserna av WP2, ”Ansluta AI med jordbrukssektorn: aktuell status och behovsbedömning”.

AI4Agri-projektet skapades för att utveckla nya digitala och gröna färdigheter för en grönare och digitaliserad arbetsmarknad inom jordbruksindustrin. Den aktuella slutanalysrapporten fungerar som ett första steg för att uppnå detta syfte och har utvecklats för att 1) analysera nuvarande EU- och nationella policyer och förordningar relaterade till jordbruk och AI, 2) diskutera hur AI-teknik anpassas och implementeras i de fyra deltagande länderna, Polen, Sverige, Cypern och Grekland, 3) ge en omfattande översikt över AI-teknik, metoder och verktyg som för närvarande används inom jordbruket, 4) identifiera och registrera tillgängliga pedagogiska metoder och utbildningsprogram relaterade till att ta itu med den digitala kompetensgapet bland jordbruksarbetare, 5) identifiera bästa praxis och framgångsrika utbildningsinitiativ i de fyra länderna, och 6) identifiera luckor och behov hos jordbruksarbetare och potentiella entreprenörer när det gäller att lära sig och anta AI-användningar inom jordbruket.

Skrivbordsundersökningar har genomförts för att ge en översikt över AI-användningar inom jordbruket, bästa praxis, tillgängliga pedagogiska metoder och utbildningsprogram (för att uppfylla de fem syften som nämns ovan). Å andra sidan har undersökningar och rundabordssamtal genomförts för att uppfylla målet att identifiera jordbruksarbetares och entreprenörers AI-relaterade kunskaper, behov och kompetensluckor (för att uppfylla det sjätte målet som nämns ovan). Detta är avgörande eftersom utvecklingen av den aktuella rapporten kommer att bidra till utvecklingen av respektive utbildningsbehov i WP4, som är AI4Agri-läroplanen och utbildningen.

Europeiska unionen (EU) har en omfattande uppsättning jordbruksbestämmelser för att garantera en stabil livsmedelsförsörjning, säkra jordbrukarnas inkomster och bevara miljön. Dessa regler utvecklas ständigt för att hantera nya utmaningar och möjligheter, och de erkänner i allt högre grad teknikens potential att förändra jordbrukssektorn. Den gemensamma jordbrukspolitiken (CAP) är hörnstenen i EU jordbrukspolitik och har ett övergripande mål om digitalisering, kunskap och innovation. Den europeiska gröna given och EUnuvarande jordbrukspolitik är nära kopplade till varandra eftersom de båda syftar till att främja hållbarhet och motståndskraft, även inom jordbrukssektorn. I den europeiska gröna given behandlas klimatneutralitet, bevarande av biologisk mångfald, cirkulär ekonomi, hållbara livsmedelssystem samt digitalisering och innovation.

De enorma möjligheter som AI erbjuder - allt från precisionsjordbruk, optimering av djurhållning, innovation i leveranskedjan till prediktiv analys och autonoma maskiner - revolutionerar traditionella jordbruksmetoder och ger jordbrukarna avancerade verktyg och insikter. AI har ett stort löfte för att förbättra jordbrukets produktivitet, effektivitet och hållbarhet, och formar framtidens livsmedelsproduktion och den globala livsmedelsförsörjningen.

I de flesta länder i Europa håller man dock fortfarande på att utforska den omvandlingspotential som AI och annan digital teknik har inom jordbrukssektorn, trots att den har utvecklats snabbt under de senaste åren.

Granskningen och analysen av AI, jordbruksteknik och lantbruksdrivna innovationer och bästa praxis på fältet i de fyra länderna visade att AI inom precisionsjordbruk revolutionerar jordbruket i Polen. Med ett rikt jordbruksarv och ett engagemang för att anamma tekniska framsteg utnyttjar Polen AI för att ta itu med viktiga utmaningar och låsa upp möjligheter inom sitt jordbrukslandskap. Sverige vill bli en global ledare inom innovation och användning av digitala lösningar, och en av teknikerna för att uppnå detta mål är AI. I Sverige växer användningen av AI inom jordbruket snabbt, eftersom jordbrukarna försöker förbättra produktiviteten och hållbarheten. I Cypern har man under de senaste åren infört flera initiativ för att stimulera jordbrukssektorn, men jordbruksmetoderna är fortfarande mer ”traditionella” med en begränsad tillämpning av ”smarta” metoder. I Grekland är framväxten av AI inom jordbruket värd att notera, med landets digitala strategi som syftar till att integrera AI i olika jordbruksmetoder och de flera pedagogiska metoder och utbildningsprogram från universitet och finansierade program som genomförs för att ta itu med den digitala kompetensgapet bland jordbruksarbetare.

Undersökningen som genomfördes i de fyra länderna visade dock att det i alla fyra länderna finns ett brett spektrum av kunskapsbrister i ämnetI Polen har de en genomsnittlig kunskap om de viktigaste anpassningsfaktorerna för teknikanvändning inom jordbruket. I Sverige har de den högsta medvetenheten om AI, men detta är inte förknippat med praktisk erfarenhet av AI-applikationer. De verkar också vara medvetna om de miljömässiga fördelarna med AI-användning inom jordbruket och den effektiva förbättringen och produktiviteten i jordbruksmetoderna. I de övriga länderna verkar däremot bara hälften av deltagarna vara medvetna om de ovannämnda fördelarna. På Cypern är kunskapsnivån och implementeringen av AI inom jordbruket mycket låg. I Grekland är de flesta av de anställda antingen vagt bekanta eller inte alls bekanta med sådana koncept, det finns ett litet antal som arbetar med AI-teknik men i allmänhet saknas kunskap.

Slutligen visade både undersökningen och rundabordssamtalen att det finns en betydande kompetensbrist bland jordbruksarbetare och entreprenörer. Det finns ett behov av att öka medvetenheten om digitaliseringen av jordbruket, AI bidrag till hållbar utveckling och grönt beslutsfattande. Det finns också ett tydligt behov av skräddarsydda utbildningsprogram som fokuserar på praktiska tillämpningar av AI inom jordbruket.

Både jordbruksarbetare och entreprenörer bör utbildas i (1) grundläggande digitala färdigheter, för att få en allmän överblick och förståelse för hur man använder digitala verktyg och plattformar så att man vet hur man använder AI-verktygen i de olika applikationerna, (2) dataanalys, förståelse för hur man tolkar och använder data kan bidra till att förbättra beslutsfattandet och öka produktiviteten, (3) mjuka färdigheter som kommunikation och problemlösning, och (4) gröna färdigheter och hållbara metoder för att utveckla en gemensam förståelse.

# ΠΕΡΙΛΗΨΗ

Η παρούσα έκθεση, παραδοτέο Α.2.4, «Παράδοση Τελικής Ανάλυσης AI4Agri», εκπονήθηκε στο πλαίσιο του συγχρηματοδοτούμενου Ευρωπαϊκού Προγράμματος Erasmus+, με τίτλο «Ανάπτυξη πράσινων και ψηφιακών δεξιοτήτων για τη χρήση της τεχνητής νοημοσύνης στη γεωργία» και ακρωνύμιο AI4Agri. Αποτελεί μέρος των παραδοτέων του Πακέτου Εργασίας 2, « Σύνδεση της τεχνητής νοημοσύνης με τον αγροτικό τομέα: τρέχουσα κατάσταση και εκτίμηση αναγκών».

Το έργο AI4Agri δημιουργήθηκε με σκοπό την ανάπτυξη νέων ψηφιακών και πράσινων δεξιοτήτων για μια πιο πράσινη και ψηφιοποιημένη αγορά εργασίας στην αγροτική βιομηχανία. Η παρούσα τελική έκθεση λειτουργεί ως ένα πρώτο βήμα για την επίτευξη αυτού του σκοπού και έχει αναπτυχθεί για να 1) αναλύσει τις τρέχουσες πολιτικές και κανονισμούς της ΕΕ και των κρατών μελών που σχετίζονται με τη γεωργία και την τεχνητή νοημοσύνη, 2) συζητήσει πώς προσαρμόζονται και εφαρμόζονται οι τεχνολογίες τεχνητής νοημοσύνης στις τέσσερις συμμετέχουσες χώρες, Πολωνία, Σουηδία, Κύπρο και Ελλάδα 3) παρέχει μια ολοκληρωμένη επισκόπηση των τεχνολογιών, μεθόδων και εργαλείων τεχνητής νοημοσύνης που χρησιμοποιούνται σήμερα στη γεωργία, 4) εντοπίσει και καταγράψει τις διαθέσιμες παιδαγωγικές προσεγγίσεις και προγράμματα κατάρτισης που σχετίζονται με την αντιμετώπιση του χάσματος ψηφιακών δεξιοτήτων μεταξύ των εργαζομένων στη γεωργία, 5) εντοπίσει βέλτιστες πρακτικές και επιτυχημένες πρωτοβουλίες κατάρτισης στις τέσσερις χώρες, 6) εντοπίσει κενά και ανάγκες των εργαζομένων στη γεωργία και δυνητικών επιχειρηματιών στον κλάδο όσον αφορά την εκμάθηση και την υιοθέτηση χρήσεων τεχνητής νοημοσύνης στη γεωργία.

Συγκεκριμένα, διεξήχθη έρευνα γραφείου για να δοθεί μια επισκόπηση των χρήσεων της τεχνητής νοημοσύνης στη γεωργία, των βέλτιστων πρακτικών, των διαθέσιμων παιδαγωγικών προσεγγίσεων και των προγραμμάτων κατάρτισης (ώστε να εκπληρωθούν οι 5 στόχοι που αναφέρονται παραπάνω). Επίσης, διενεργήθηκαν έρευνες και συζητήσεις στρογγυλής τραπέζης για τον εντοπισμό των γνώσεων, των αναγκών και των ελλείψεων δεξιοτήτων των εργαζομένων και των επιχειρηματιών στον τομέα της γεωργίας σχετικά με την τεχνητή νοημοσύνη (για την εκπλήρωση του 6ου στόχου που αναφέρεται παραπάνω). Αυτό είναι ιδιαίτερα σημαντικό, καθώς η ανάπτυξη της παρούσας έκθεσης θα συμβάλει στην ανάπτυξη των αντίστοιχων εκπαιδευτικών αναγκών του Πακέτου Εργασίας 4, δηλαδή του προγράμματος σπουδών και της κατάρτισης AI4Agri.

Η Ευρωπαϊκή Ένωση (ΕΕ) διαθέτει ένα ολοκληρωμένο σύνολο κανονισμών για τη γεωργία, προκειμένου να διασφαλίσει τη σταθερή προμήθεια τροφίμων, να εξασφαλίσει το εισόδημα των αγροτών και να διαφυλάξει το περιβάλλον. Οι πολιτικές αυτές εξελίσσονται διαρκώς για την αντιμετώπιση νέων προκλήσεων και ευκαιριών και αναγνωρίζουν ολοένα και περισσότερο τις δυνατότητες της τεχνολογίας για τον μετασχηματισμό του αγροτικού τομέα. Η Κοινή Γεωργική Πολιτική (ΚΓΠ) αποτελεί τον ακρογωνιαίο λίθο της γεωργικής πολιτικής της ΕΕ έχοντας ως οριζόντιους στόχους τη ψηφιοποίηση, τη γνώση και την καινοτομία. Η Ευρωπαϊκή Πράσινη Συμφωνία και οι τρέχουσες γεωργικές πολιτικές της ΕΕ συνδέονται στενά, καθώς και οι δύο στοχεύουν στην προώθηση της βιωσιμότητας και της ανθεκτικότητας, όπως επίσης και στον αγροτικό τομέα. Γενικότερα, η Ευρωπαϊκή Πράσινη Συμφωνία αφορά την κλιματική ουδετερότητα, τη διατήρηση της βιοποικιλότητας, την κυκλική οικονομία, τα βιώσιμα συστήματα τροφίμων, την ψηφιοποίηση και την καινοτομία.

Η τεχνητή νοημοσύνη προσφέρει τεράστιες δυνατότητες, από τη γεωργία ακριβείας, τη βελτιστοποίηση της διαχείρισης ζώων, την καινοτομία της αλυσίδας εφοδιασμού έως την προγνωστική ανάλυση και τα αυτόνομα μηχανήματα, η τεχνητή νοημοσύνη φέρνει επανάσταση στις παραδοσιακές μεθόδους γεωργίας, ενδυναμώνοντας τους αγρότες με προηγμένα εργαλεία και γνώσεις και υπόσχεται τεράστια οφέλη στη βελτίωση της γεωργικής παραγωγικότητας, την αποδοτικότητα και τη βιωσιμότητα, διαμορφώνοντας το μέλλον της παραγωγής τροφίμων και της παγκόσμιας επισιτιστικής ασφάλειας.

Παρόλα αυτά, στις περισσότερες χώρες της Ευρώπης, εξακολουθούν να διερευνούν τις δυνατότητες της τεχνητής νοημοσύνης και άλλων ψηφιακών τεχνολογιών στον αγροτικό τομέα, παρόλο που τα τελευταία χρόνια αυτή αναπτύσσεται ραγδαία.

Η ανασκόπηση και ανάλυση σχετικά με την τεχνητή νοημοσύνη, τη γεωργική τεχνολογία, τις καινοτομίες και τις βέλτιστες πρακτικές των αγροτών στις τέσσερις χώρες έδειξαν τα εξής: η τεχνητή νοημοσύνη στη γεωργία ακριβείας φέρνει επανάσταση στη γεωργία στην Πολωνία. Με πλούσια αγροτική κληρονομιά και δέσμευση να αγκαλιάσει τις τεχνολογικές εξελίξεις, η Πολωνία αξιοποιεί την τεχνητή νοημοσύνη για να αντιμετωπίσει βασικές προκλήσεις και να ξεκλειδώσει ευκαιρίες στο αγροτικό της τοπίο. Η Σουηδία θέλει να γίνει παγκόσμιος ηγέτης στον τομέα της καινοτομίας και της χρήσης ψηφιακών λύσεων και μία από τις τεχνολογίες για την επίτευξη αυτού του στόχου είναι η τεχνητή νοημοσύνη. Στη Σουηδία, η χρήση της τεχνητής νοημοσύνης στη γεωργία αυξάνεται ραγδαία, καθώς οι αγρότες επιδιώκουν να βελτιώσουν την παραγωγικότητα και τη βιωσιμότητα. Στην Κύπρο, αν και τα τελευταία χρόνια έχουν εισαχθεί αρκετές πρωτοβουλίες για την ενίσχυση του αγροτικού τομέα, οι γεωργικές πρακτικές είναι πιο «παραδοσιακές» με περιορισμένη εφαρμογή «έξυπνων» πρακτικών. Στην Ελλάδα, αξίζει να σημειωθεί η εμφάνιση της τεχνητής νοημοσύνης στη γεωργία, με την ψηφιακή στρατηγική της χώρας να στοχεύει στην ενσωμάτωση της τεχνητής νοημοσύνης σε διάφορες γεωργικές πρακτικές και τις διάφορες παιδαγωγικές προσεγγίσεις και προγράμματα κατάρτισης από πανεπιστήμια και χρηματοδοτούμενα προγράμματα που εφαρμόζονται για την αντιμετώπιση του χάσματος ψηφιακών δεξιοτήτων μεταξύ των εργαζομένων στη γεωργία.

Ωστόσο, η έρευνα αξιολόγησης αναγκών που διεξήχθη στις τέσσερις χώρες αποκάλυψε ότι και οι τέσσερις χώρες υστερούν σε ένα ευρύ φάσμα γνώσεων σχετικά με το θέμα.

Στην Πολωνία, κατέχουν μέτρια γνώση των κύριων προσαρμοστικών παραγόντων της χρήσης τεχνολογίας στη γεωργία. Στη Σουηδία έχουν το υψηλότερο επίπεδο ενημέρωσης σχετικά με την τεχνητή νοημοσύνη, αλλά αυτό δεν σχετίζεται με την πρακτική εμπειρία σε εφαρμογές τεχνητής νοημοσύνης. Φαίνεται επίσης να γνωρίζουν τα περιβαλλοντικά οφέλη από τη χρήση της τεχνητής νοημοσύνης στη γεωργία και την αποτελεσματική βελτίωση και παραγωγικότητα στις γεωργικές πρακτικές. Αντίθετα, στις υπόλοιπες χώρες, μόνο οι μισοί από τους συμμετέχοντες φαίνεται να γνωρίζουν τα προαναφερθέντα οφέλη. Στην Κύπρο υπάρχει πολύ χαμηλό επίπεδο γνώσης και εφαρμογής της χρήσης τεχνητής νοημοσύνης στη γεωργία. Παρόμοια, στην Ελλάδα, το μεγαλύτερο μέρος του εργατικού δυναμικού είτε είναι ελάχιστα εξοικειωμένο είτε δεν είναι καθόλου εξοικειωμένο με τέτοιες έννοιες, υπάρχει ένας μικρός αριθμός που εργάζεται με τεχνολογίες τεχνητής νοημοσύνης αλλά γενικότερα υπάρχει έλλειψη γνώσης.

Τέλος, τόσο τα αποτελέσματα της έρευνας όσο και των συζητήσεων στρογγυλής τραπέζης αποκάλυψαν σημαντικό χάσμα δεξιοτήτων μεταξύ των εργαζομένων και των επιχειρηματιών στον τομέα της γεωργίας. Υπάρχει ανάγκη για ενημέρωση σχετικά με την ψηφιοποίηση της γεωργίας, τη συμβολή της τεχνητής νοημοσύνης στη βιώσιμη ανάπτυξη και τη λήψη πράσινων αποφάσεων. Υπάρχει επίσης σαφής ανάγκη για εξατομικευμένα προγράμματα κατάρτισης που να εστιάζουν σε πρακτικές εφαρμογές της τεχνητής νοημοσύνης στη γεωργία.

Τόσο οι εργαζόμενοι στη γεωργία όσο και οι επιχειρηματίες θα πρέπει, ιδανικά, να εκπαιδευτούν σε: (1) βασικές ψηφιακές δεξιότητες, ώστε να έχουν μια γενική επισκόπηση και κατανόηση του τρόπου χρήσης ψηφιακών εργαλείων και πλατφορμών, για να γνωρίζουν πώς να χρησιμοποιούν τα εργαλεία τεχνητής νοημοσύνης των διαφόρων εφαρμογών (2) ανάλυση δεδομένων, η κατανόηση του τρόπου ερμηνείας και χρήσης δεδομένων μπορεί να συμβάλει στη βελτίωση της λήψης αποφάσεων και στην αύξηση της παραγωγικότητας, (3) κοινωνικές δεξιότητες όπως η επικοινωνία και η επίλυση προβλημάτων και (4) πράσινες δεξιότητες και βιώσιμες πρακτικές για την ανάπτυξη μιας κοινής αντίληψης.

# INTRODUCTION

The rise of artificial intelligence has created growing excitement about its potential to revolutionize entire industries, including the agriculture industry. The European Grean Deal implementation along with the shift towards new technologies and digitalisation are key drivers for the industry leading to the need of upskilling and reskilling of the existing and newcomer entrepreneurs.

The AI4Agri project emerges as a crucial initiative within the European Union's agricultural sector, recognizing the critical role agriculture plays in climate change mitigation efforts. By prioritizing environmental sustainability and digital transformation, AI4Agri not only raises awareness of AI's potential in agriculture but also cultivates the necessary skills and capacities for its adoption.

The project will apply a targeted vocational education and training program to equip agricultural workers and entrepreneurs with the latest knowledge and competencies. This approach ensures the adaptation of the workforce to emerging trends, driving progress towards the Sustainable Development Goals and aligning with the EU's environmental objectives.

This Final AI4Agri Analysis, incorporates (i) the review and analysis on AI, agriculture technology and farmer-driven innovations and best-practices on the field in the four countries of the consortium, Poland, Sweden, Cyprus and Greece; (ii) the survey analysis on needs assessment conducted in the four countries; (iii) the Reflection Roundtables national results.

## Review and analysis on AI, agriculture technology and farmer-driven innovations and best-practices on the field

The main aim of the Needs Assessment was to conduct a comprehensive review of AI and agriculture technology, focusing on farmer-driven innovations and best practices in the four countries of the consortium, in order to identify current practices, tools, and models in use at both national and European levels, shedding light on existing pathways towards AI integration and uncovering gaps in policies related to AI ethics and technology adoption, particularly among small farmers.
The research focus on:

1. Agriculture Policies in the EU: Analyses current EU policies related to agriculture, including any provisions for AI integration.
2. AI Policies in the EU: Examines existing EU policies and regulations concerning AI, with a focus on their impact on the agricultural sector.
3. Adaptation at National Contexts: Discusses how AI technologies are being adapted and implemented in each country.
4. National Legislation Frameworks: Evaluates national legal frameworks and regulations governing AI use in agriculture.
5. AI Technologies & Applications in Agriculture Industry: Provides a comprehensive overview of AI technologies, methods, and tools currently employed in agriculture and highlights successful AI applications and their impact on agricultural productivity.
6. Pedagogical Practices and Trainings: Investigates pedagogical approaches and training programs that are addressing the digital literacy gap among agriculture workers and identify best practices and successful training initiatives.

The National reports were validated from an agricultural expert in each country. In Poland it was validated by dr hab. inż. Andrzej Borusiewicz, in Sweden by Joseph Olugbenga Kayode, in Cyprus by Charis Nikolaidis and in Greece by Stavroula Katsoulakou.

# Review and analysis on AI, agriculture technology and farmer-driven innovations and best-practices on the field in Poland

## 1. Introduction

The integration of artificial intelligence (AI) technologies into agriculture represents a pivotal moment in the evolution of modern farming practices. With the world's population steadily increasing and agricultural resources becoming increasingly constrained, there is a pressing need for innovative solutions to enhance productivity, efficiency, and sustainability in food production. AI offers unprecedented opportunities to address these challenges by revolutionizing traditional farming methods and empowering farmers with advanced tools and technologies to optimize agricultural processes.

In this chapter, we explore the intersection of agriculture and AI, with a special focus on Poland, delving into the transformative potential of AI technologies and their implications for the future of farming. From precision agriculture and crop monitoring to predictive analytics and autonomous machinery, we examine the diverse applications of AI in agriculture and the profound impact they are having on agricultural productivity, resource management, and environmental sustainability. By highlighting key advancements, best practices, and emerging trends in the field, this chapter aims to provide a comprehensive overview of the role of AI in shaping the future of agriculture and driving innovation in the global food system.

In Poland, the connection between agriculture and artificial intelligence (AI) is propelling the sector into a new era of innovation and efficiency. With a rich agricultural heritage and a commitment to embracing technological advancements, Poland is leveraging AI to address key challenges and unlock opportunities within its agricultural landscape. From precision farming to supply chain optimization, AI is being deployed across various aspects of agricultural operations to enhance productivity, sustainability, and competitiveness. (Digital Poland Foundation, 2019).

One area where AI is making significant strides in Poland is precision agriculture. Through the use of AI-powered sensors, drones, and satellite imagery, Polish farmers can gather real-time data on soil conditions, crop health, and environmental factors. By analysing this data using advanced machine learning algorithms, farmers can make data-driven decisions regarding irrigation, fertilization, and pest control. This precision approach not only maximizes crop yields but also minimizes resource inputs, leading to more sustainable farming practices. (EARSC, 2019).

Furthermore, AI is revolutionizing livestock management in Poland. By deploying AI-powered monitoring systems and wearable devices, farmers can track key parameters such as animal health, behaviour, and productivity in real-time. Machine learning algorithms analyse this data to detect anomalies and predict potential health issues, enabling farmers to intervene early and prevent losses. Additionally, AI is optimizing breeding programs, improving feed efficiency, and enhancing overall farm profitability in the livestock sector. (Cain, 2024).

## 2. Agriculture Policies in Poland

Agriculture holds a significant place in Poland's economy and cultural heritage, with a rich history of farming dating back centuries. Situated in Central Europe, Poland boasts diverse landscapes, ranging from fertile plains to rolling hills and picturesque countryside. This geographical diversity has shaped the country's agricultural sector, supporting a wide array of crops and livestock production. Livestock farming also plays a significant role in Poland's agricultural landscape. Dairy farming, in particular, is widespread, with Poland being one of the leading milk producers in the European Union. Cattle, pigs, and poultry are raised on both large-scale commercial farms and smaller family-owned operations, contributing to the country's vibrant livestock sector. (GOV, 2005).

Grains, particularly wheat, barley, and rye, are staple crops in Poland, cultivated extensively across the country's vast agricultural lands. Additionally, Poland is a major producer of potatoes, sugar beets, and other root crops, contributing to its role as a key supplier of agricultural products within Europe. The fertile soils of regions such as Wielkopolska, Mazovia, and Podlasie have long been renowned for their agricultural productivity, supporting high yields and diverse crop rotations. (SUFISA, 2018).

Especially in recent years, Poland has witnessed modernization and technological advancements in its agricultural practices. Mechanization, precision farming techniques, and the adoption of digital technologies have enabled farmers to increase efficiency, improve yields, and enhance sustainability. Moreover, Poland's accession to the European Union has facilitated access to subsidies, grants, and support programs under the Common Agricultural Policy (CAP), which have played a vital role in modernizing the sector and improving the livelihoods of farmers. (Kosior, 2023).

Despite these advancements, Polish agriculture faces challenges such as land fragmentation, aging farm population, and environmental concerns. Efforts to address these challenges include land consolidation initiatives, support for young farmers, and the promotion of sustainable farming practices. Additionally, Poland is increasingly focusing on agroecology, biodiversity conservation, and organic farming to mitigate environmental impacts and promote resilience in the face of climate change. (Hornowski, 2020).

Poland, like many other countries, had been gradually embracing technological advancements, including AI, in various sectors, including agriculture. Governments often see AI integration in agriculture as a means to improve efficiency, increase yields, optimize resource use, and address challenges such as climate change and food security. (EC, 2021). Policies related to agriculture in Poland may encompass various aspects such as subsidies, environmental regulations, land management, rural development programs, and support for farmers. The extent to which AI integration is explicitly addressed in these policies would depend on the government's priorities, technological readiness, and the perceived benefits of AI in agriculture. (ibid.)

Poland had several agricultural policies in place aimed at supporting its agricultural sector, ensuring food security, and promoting rural development. One of the primary mechanisms through which Poland addressed these objectives was by accessing funds and support mechanisms provided through the European Union's Common Agricultural Policy (CAP). These funds were crucial for Poland, as they provided financial resources to support farmers, improve agricultural productivity, promote sustainable farming practices, and enhance rural infrastructure and development projects. (EC, 2023).

Within the framework of CAP, Poland implemented various subsidy and support programs tailored to the needs of its agricultural sector. Direct payments to farmers formed a significant component of these subsidies, providing income stabilization and support for farm operations. Additionally, Poland offered agri-environmental schemes aimed at incentivizing farmers to adopt environmentally friendly practices while ensuring the sustainable management of natural resources. Rural development programs were also integral, focusing on investments in rural infrastructure, diversification of rural economies, and the enhancement of agricultural competitiveness. Environmental sustainability was a key consideration in Poland's agricultural policies. The government implemented regulations to address soil conservation, water management, and biodiversity protection within the agricultural sector. These regulations were often aligned with EU directives and aimed to promote sustainable farming practices while minimizing adverse environmental impacts. (ibid.)

Furthermore, Poland had policies governing land management, including land ownership regulations, land use planning, and land consolidation initiatives. These policies aimed to optimize agricultural land usage, prevent land fragmentation, and facilitate more efficient farming practices, thereby contributing to increased agricultural productivity and profitability. Investment in research, innovation, and technology transfer has long been recognized as a crucial pillar of Poland's agricultural policies, signifying the country's commitment to fostering agricultural advancement and sustainability. (Janus, 2021). Through strategic allocation of resources, the Polish government has continuously supported agricultural research institutions, aiming to spur innovation in farming practices and facilitate the seamless adoption of cutting-edge technologies by farmers nationwide. The emphasis on innovation within Poland's agricultural sector is multifaceted, encompassing initiatives aimed at improving productivity, resilience, and adaptability in the face of evolving challenges such as climate change and market volatility. By investing in research and development, Poland seeks to develop robust farming systems capable of withstanding environmental stressors while meeting the growing demands of a dynamic global market. (GOV, 2005).

While explicit policies specifically addressing the integration of artificial intelligence (AI) in agriculture may not have been formalized at the time of the last update, Poland, like many other nations, is undoubtedly exploring the transformative potential of AI and other digital technologies within its agricultural landscape. The vast possibilities offered by AI, ranging from precision agriculture to predictive analytics and autonomous machinery, hold immense promise for enhancing agricultural productivity, efficiency, and sustainability. (EC, 2021).

In the realm of precision agriculture, AI-powered solutions enable farmers to optimize resource allocation and enhance crop management practices through real-time data analysis. Remote sensing technologies and advanced analytics empower farmers to monitor crop health, predict yield fluctuations, and make informed decisions regarding irrigation, fertilization, and pest management strategies. Furthermore, the deployment of AI-powered autonomous machinery revolutionizes traditional farming operations by increasing efficiency and reducing labour-intensive tasks. These technologies streamline agricultural workflows, minimize operational costs, and improve overall farm productivity, thus positioning Poland's agricultural sector for continued growth and competitiveness in a rapidly evolving global market. (Nayak, 2024).

As Poland continues to explore the integration of AI and digital technologies in agriculture, staying informed about the latest developments and policy initiatives is essential. For the most up-to-date information on Poland's agricultural policies and any provisions for AI integration, stakeholders are encouraged to consult recent government publications, reports from agricultural authorities, or reputable news sources covering agricultural advancements in Poland. By remaining vigilant and proactive, Poland can leverage AI to drive innovation and sustainability within its agricultural sector, ensuring a prosperous future for farmers and stakeholders alike. (EC, 2021).

## 3. AI Policies in Poland

Artificial intelligence (AI) has emerged as a transformative force in agriculture worldwide, and Poland, as one of the major agricultural producers in Europe, is actively embracing AI technologies to modernize its farming practices and tackle various challenges facing the sector. With advancements in machine learning, predictive analytics, and robotics, Polish farmers are leveraging AI-driven solutions to optimize crop management, increase yields, and make data-informed decisions that drive efficiency and sustainability across the agricultural value chain. (Loon, 2023).

Precision farming stands out as a prominent area where AI is revolutionizing agriculture in Poland. By harnessing AI-powered sensors, drones, and satellite imagery, farmers can gather detailed insights into soil conditions, crop health, and environmental factors, enabling them to implement precise interventions tailored to the specific needs of their fields. This data-driven approach allows for optimized resource allocation, including precise irrigation, fertilization, and pest management, resulting in higher yields, reduced input costs, and minimized environmental impact. (ibid.). The adoption of precision farming practices empowered by AI has the potential to revolutionize agricultural productivity in Poland, unlocking new levels of efficiency and sustainability for farmers.

Furthermore, AI-driven predictive analytics is proving to be a game-changer for Polish farmers, enabling them to anticipate and mitigate risks associated with pests, diseases, and adverse weather conditions. By analysing historical data alongside real-time environmental parameters, AI algorithms can generate accurate forecasts and early warning alerts for potential threats to crops, allowing farmers to take proactive measures to protect their harvests. Whether it's implementing targeted pest control strategies or adjusting planting schedules in response to weather forecasts, AI-powered predictive analytics empowers Polish farmers to make informed decisions that optimize yields and minimize losses, ultimately enhancing the resilience of agricultural operations. (Nayak, 2024).

In addition to crop management, AI technologies are revolutionizing livestock farming practices in Poland. Through the integration of AI-powered sensors and monitoring systems, farmers can track the health, behaviour, and productivity of their livestock with unprecedented precision and efficiency. Real-time data insights enable early detection of health issues and enable timely interventions, such as administering medical treatment or adjusting feed formulations, to ensure the well-being of animals and optimize production outcomes. (Cain, 2024). Moreover, AI-driven technologies enable farmers to optimize breeding programs, improve feed efficiency, and enhance overall farm profitability in livestock operations across Poland.

The deployment of AI-driven robotics is also gaining momentum in Polish agriculture, offering opportunities to automate labour-intensive tasks and streamline farm operations. Autonomous agricultural robots equipped with AI capabilities are increasingly being deployed in fields and greenhouses to perform tasks such as planting, weeding, and harvesting with precision and efficiency. By leveraging advanced computer vision and machine learning algorithms, these robots can navigate complex agricultural environments, identify crops and weeds, and execute tasks autonomously, reducing the need for manual labour and increasing operational efficiency. (Loon, 2023). The adoption of AI-powered robotics in Polish agriculture not only enhances productivity but also improves working conditions for farmers and addresses labour shortages in the sector.

Moreover, AI is facilitating the development of smart agricultural systems that enable seamless integration and interoperability of farm equipment, sensors, and data analytics platforms. Through the Internet of Things (IoT) and AI technologies, Polish farmers can create interconnected farm ecosystems where data flows seamlessly between different devices and systems, enabling real-time monitoring and control of agricultural processes. This interconnectedness empowers farmers to optimize resource utilization, improve decision-making, and enhance operational efficiency across the entire farm operation, from field to fork. (Nayak, 2024).

Despite the significant advancements in AI adoption in Polish agriculture, several challenges persist, including issues related to data privacy, cybersecurity, and digital infrastructure. Addressing these challenges requires concerted efforts from policymakers, industry stakeholders, and research institutions to develop robust frameworks for data governance, promote digital literacy among farmers, and invest in the necessary infrastructure to support AI-driven innovation in agriculture. By overcoming these barriers and fostering a supportive ecosystem for AI adoption, Poland can unlock the full potential of AI technologies to drive sustainable growth and innovation in its agricultural sector, ensuring food security, environmental stewardship, and economic prosperity for generations to come. (UNESCO, 2019).

Furthermore, the integration of AI in Polish agriculture has far-reaching implications for rural development, economic growth, and environmental sustainability. By leveraging AI-driven technologies, Polish farmers can enhance their competitiveness in domestic and international markets, driving economic growth and prosperity in rural communities. Additionally, AI-enabled precision farming practices help reduce the environmental footprint of agriculture by minimizing the use of water, fertilizers, and pesticides, mitigating soil erosion, and preserving biodiversity. (EC, 2021). As Poland seeks to transition towards more sustainable and resilient agricultural systems, AI will play a pivotal role in shaping the future of farming in the country.

Moreover, the adoption of AI technologies in Polish agriculture opens up new opportunities for collaboration, innovation, and knowledge exchange within the agricultural ecosystem. Research institutions, technology companies, and government agencies can collaborate with farmers to develop and deploy AI-driven solutions that address specific challenges faced by the sector. By fostering a culture of innovation and entrepreneurship, Poland can harness the collective expertise and creativity of its agricultural community to drive continuous improvement and innovation in farming practices. (ibid.)

Furthermore, AI has the potential to revolutionize the way food is produced, processed, and distributed in Poland. AI-powered technologies can optimize supply chain management, improve food safety standards, and enhance traceability throughout the food production process. By leveraging AI-driven analytics, food producers can gain valuable insights into consumer preferences, market trends, and demand patterns, enabling them to tailor their products to meet the evolving needs of consumers. Additionally, AI-enabled robotics and automation can streamline food processing and packaging operations, increasing efficiency and reducing waste in the food production chain. (McNamara, 2023).

Briefly, the integration of AI technologies in Polish agriculture represents a significant opportunity to drive innovation, efficiency, and sustainability in the sector. By harnessing the power of AI-driven solutions, Polish farmers can optimize resource use, improve productivity, and mitigate risks associated with climate change and market volatility. However, realizing the full potential of AI in agriculture requires collaboration, investment, and a supportive policy environment that enables the adoption and deployment of AI technologies across the entire agricultural value chain. With the right strategies and investments in place, Poland can position itself as a leader in AI-driven agriculture, ensuring the long-term viability and competitiveness of its agricultural sector in the global marketplace.

## 4. Adaptation of AI at the National Contexts.

In Poland, the integration of AI technologies into agriculture represents a monumental leap forward, ushering in a transformative era of innovation, productivity, and sustainability within the sector. Across various facets of agricultural practices, AI-driven applications are being meticulously adapted and strategically implemented to confront specific challenges while optimizing every aspect of farm management processes. This concerted effort is propelling Polish agriculture into a new epoch characterized by precision, efficiency, and resilience, positioning the sector for sustained growth and competitiveness in the global market. (Loon, 2023).

Precision agriculture stands as a cornerstone domain profoundly impacted by the advancements in AI technology. Through the strategic deployment of AI-powered sensors, drones, and satellite imagery, Polish farmers are empowered to collect and analyse intricate datasets pertaining to soil conditions, crop health, and environmental parameters with unprecedented accuracy and granularity. This wealth of data serves as the cornerstone for informed decision-making, allowing farmers to optimize resource allocation, implement targeted interventions for irrigation, fertilization, and pest control, and ultimately, amplify crop yields while minimizing input costs. By embracing precision agriculture methodologies augmented by AI, farmers across Poland are not merely maximizing productivity but also spearheading efforts towards a more sustainable agricultural ecosystem, where efficiency and environmental stewardship go hand in hand. (Nayak, 2024).

Moreover, the advent of predictive analytics fuelled by AI technologies has emerged as a game-changer for Polish farmers in mitigating risks associated with pests, diseases, and adverse weather conditions. By harnessing historical data alongside real-time environmental indicators, AI algorithms generate precise forecasts and timely alerts, empowering farmers to proactively implement preventive measures. Whether it's adjusting planting schedules, deploying targeted pest management strategies, or optimizing crop rotations, AI-driven predictive analytics plays a pivotal role in safeguarding crop yields and ensuring the overall health of agricultural operations throughout Poland.

In the realm of livestock farming, AI-driven monitoring and management systems are spearheading a revolution in traditional husbandry practices. Through the strategic deployment of AI-powered sensors and monitoring devices, farmers gain invaluable insights into critical parameters such as feed intake, activity levels, and health indicators among their livestock in real-time. This enables early detection of health issues and facilitates prompt intervention, thereby enhancing animal welfare and optimizing production outcomes. Furthermore, AI-driven analytics are revolutionizing breeding programs, improving feed efficiency, and bolstering overall farm profitability in livestock operations across Poland, contributing to the sector's competitiveness and sustainability. (CABI, 2024). The deployment of autonomous farming machinery equipped with AI capabilities is gaining rapid momentum across Polish farms, heralding a new era of labour efficiency and operational optimization. These AI-powered robots, adept at executing a diverse array of tasks with remarkable precision and efficiency, are revolutionizing farm operations. By diminishing the reliance on manual labour, autonomous farming machinery not only amplifies productivity but also addresses labour shortages within the agricultural sector, thereby fostering heightened farm efficiency and profitability. (ibid.)

Furthermore, smart farming systems, underpinned by AI and the Internet of Things (IoT), are fostering seamless integration and interoperability of farm equipment, sensors, and data analytics platforms. This interconnectedness facilitates real-time monitoring and control of agricultural processes, optimizing resource utilization, enhancing decision-making, and elevating operational efficiency across the entire agricultural value chain. Additionally, AI-driven decision support systems provide Polish farmers with invaluable insights and recommendations to fine-tune farm management practices, ensuring optimal yields, minimal risks, and enhanced profitability. (ibid.)

Beyond operational enhancements, AI technologies are playing a pivotal role in catalysing data-driven research and innovation within Poland's agricultural landscape. Research institutions, agricultural organizations, and governmental bodies are leveraging AI to analyse vast datasets, uncover patterns, and develop novel technologies and practices to address emergent challenges and seize untapped opportunities within the sector. This concerted effort in AI-driven innovation is pivotal in propelling Poland's agricultural industry onto the global stage while effectively meeting the evolving demands of consumers and stakeholders alike. (Loon, 2023).

Moreover, the adoption of AI technologies in Polish agriculture bears profound implications for rural development, economic growth, and environmental sustainability. By augmenting productivity, reducing input costs, and optimizing resource efficiency, AI-driven agriculture holds the potential to bolster the economic viability of rural communities and spawn new avenues for employment and entrepreneurship within the agricultural sector. (Nayak, 2024). Additionally, by championing sustainable farming practices and curtailing environmental impact, AI technologies can play a pivotal role in conserving natural resources and mitigating the adverse effects of climate change, thereby ensuring the long-term sustainability of agriculture in Poland.

## 5. National Legislation Frameworks.

The integration of artificial intelligence (AI) in Polish agriculture is underpinned by a comprehensive framework of legal regulations meticulously crafted to ensure the ethical, safe, and responsible use of AI technologies. These regulations serve to navigate the intricate intersection between technological innovation and agricultural practices, while also prioritizing the protection of farmers, consumers, and the environment.

Data protection legislation, notably the General Data Protection Regulation (GDPR) enforced by the European Union (EU), stands at the forefront of legal considerations governing AI adoption in agriculture in Poland. The GDPR establishes rigorous standards governing the collection, processing, and storage of personal data, including information generated by AI systems utilized in agricultural operations. Compliance with GDPR requirements is not just a legal obligation but a fundamental necessity for farmers and agricultural organizations in Poland to uphold the privacy and rights of individuals whose data is processed by AI technologies. Ensuring compliance with GDPR principles forms a crucial aspect of AI implementation strategies in the agricultural sector, where data privacy and security are paramount concerns. (EDPS, 2023).

Furthermore, intellectual property rights legislation plays a pivotal role in shaping the landscape of AI innovation within the agricultural domain in Poland. Farmers and agricultural companies are confronted with navigating a complex maze of patent rights, copyright protection, and trade secrets when developing or deploying AI technologies. Intellectual property laws provide essential legal safeguards to incentivize investment in research and development within the agricultural sector, fostering an environment conducive to innovation. Clear guidelines and robust enforcement mechanisms are essential to protect the intellectual property rights of innovators and developers, thereby promoting a vibrant ecosystem of AI-driven agricultural innovation in Poland. (Nayak, 2024).

Liability considerations constitute another significant facet of the legal frameworks governing AI adoption in Polish agriculture. As AI-powered agricultural machinery and systems become increasingly prevalent, questions regarding responsibility and accountability in the event of accidents or damages inevitably arise. Polish laws and regulations provide guidelines for determining liability in such cases, ensuring that farmers, manufacturers, and other stakeholders are held accountable for any harm caused by AI technologies in agriculture. Establishing a robust framework for risk mitigation and dispute resolution is essential to instil confidence in AI adoption among stakeholders, thereby fostering a climate conducive to innovation and growth in the agricultural sector. (ZG Legal, 2023).

Moreover, ethical considerations surrounding AI use in agriculture are addressed through a variety of legal frameworks aimed at promoting transparency, fairness, and accountability. Guidelines and codes of conduct may be established to govern the development, deployment, and use of AI technologies in agriculture, ensuring that ethical principles are upheld throughout the innovation process. These frameworks encompass provisions for ethical AI design, algorithm transparency, and stakeholder engagement, serving to mitigate potential risks and ensure that AI applications in agriculture align with societal values and expectations. Striking a balance between technological advancement and ethical considerations is paramount to fostering public trust and confidence in AI adoption in the agricultural sector. (Ryan, 2022).

Additionally, regulatory bodies and government agencies in Poland play a pivotal role in overseeing compliance with legal frameworks governing AI adoption in agriculture. These entities provide guidance, support, and oversight to ensure that AI technologies deployed in the agricultural sector adhere to applicable laws and regulations while promoting innovation, competitiveness, and sustainability. Through active engagement with industry stakeholders and continuous monitoring of technological developments, regulatory bodies endeavour to strike a delicate balance between fostering innovation and safeguarding public interests. Collaborative efforts between government agencies, industry stakeholders, and research institutions are essential to ensure that AI adoption in Polish agriculture is aligned with broader societal objectives, including economic growth, environmental sustainability, and social welfare. (EC, 2021).

In summary, the legal frameworks and regulations governing AI adoption in agriculture in Poland are multifaceted and continually evolving to keep pace with technological advancements and changing societal needs. By establishing clear rules and guidelines, Poland aims to promote responsible AI adoption in agriculture, ensuring that AI technologies contribute to the advancement of the agricultural sector while upholding ethical standards, protecting data privacy, addressing liability concerns, and fostering innovation-driven growth. Continued collaboration and dialogue among policymakers, industry stakeholders, and civil society are essential to navigate the complex challenges and opportunities presented by AI adoption in Polish agriculture effectively.

## 6. AI Technologies & Applications in Agriculture Industry

Artificial intelligence (AI) technologies have emerged as transformative tools revolutionizing various facets of agriculture, offering innovative solutions to address a multitude of challenges faced by farmers and agricultural stakeholders. Across the agricultural landscape, AI-driven applications are being deployed to optimize processes, enhance decision-making, and ultimately increase productivity, efficiency, and sustainability in food production.

Precision agriculture stands out as one of the primary domains where AI technologies are making significant strides. Through the integration of AI-powered sensors, drones, and satellite imagery, farmers can collect vast amounts of data related to soil conditions, crop health, and environmental parameters. These data streams are then analysed using advanced machine learning algorithms to generate actionable insights. By leveraging precision agriculture methodologies augmented by AI, farmers can make informed decisions regarding irrigation, fertilization, and pest management. Such data-driven approaches enable farmers to optimize resource allocation, minimize input costs, and maximize crop yields, thereby fostering a more sustainable agricultural ecosystem. (Rensburg, 2023).

Predictive analytics is another area where AI technologies are driving transformative changes in agriculture. By harnessing historical data alongside real-time environmental indicators, AI algorithms can forecast crop yields, predict pest outbreaks, and anticipate weather patterns with remarkable accuracy. These predictive insights empower farmers to proactively implement preventive measures to safeguard crop yields and mitigate risks. Whether adjusting planting schedules, deploying targeted pest management strategies, or optimizing crop rotations, AI-driven predictive analytics enables farmers to make data-driven decisions that optimize production outcomes while minimizing the impact of external factors on agricultural operations. (Nayak, 2024).

In livestock farming, AI-driven monitoring and management systems are revolutionizing traditional husbandry practices. Through the deployment of AI-powered sensors and monitoring devices, farmers gain real-time insights into critical parameters such as feed intake, activity levels, and health indicators among their livestock. Machine learning algorithms analyse these data streams to detect anomalies and identify potential health issues early on, enabling farmers to intervene promptly and enhance animal welfare. Furthermore, AI-driven analytics are optimizing breeding programs, improving feed efficiency, and bolstering overall farm profitability in livestock operations. (ibid.).

The advent of autonomous farming machinery equipped with AI capabilities is gaining momentum across agricultural landscapes, ushering in a new era of labour efficiency and operational optimization. These AI-powered robots are capable of executing a diverse array of tasks, ranging from planting and weeding to harvesting, with precision and efficiency. By reducing the reliance on manual labour, autonomous farming machinery not only amplifies productivity but also addresses labour shortages within the agricultural sector, thereby fostering heightened farm efficiency and profitability. (ibid.).

Smart farming systems, underpinned by AI and the Internet of Things (IoT), are fostering seamless integration and interoperability of farm equipment, sensors, and data analytics platforms. This interconnectedness facilitates real-time monitoring and control of agricultural processes, optimizing resource utilization, enhancing decision-making, and elevating operational efficiency across the entire agricultural value chain. Additionally, AI-driven decision support systems provide farmers with invaluable insights and recommendations to fine-tune farm management practices, ensuring optimal yields, minimal risks, and enhanced profitability. (Dhanaraju, 2022).

Innovative AI technologies such as computer vision and natural language processing are also being leveraged to address specific challenges within the agricultural sector. Computer vision algorithms can analyse images captured by drones or cameras to identify crop diseases, assess plant health, and monitor crop growth stages. Natural language processing algorithms enable farmers to interact with AI-powered chatbots or virtual assistants to access real-time information, receive personalized recommendations, and streamline decision-making processes. (Nayak, 2024).

AI applications in agriculture have had a profound impact on agricultural productivity, revolutionizing traditional farming practices and enhancing efficiency, sustainability, and resilience within the sector. These AI-driven solutions leverage advanced technologies such as machine learning, computer vision, and predictive analytics to optimize various aspects of agricultural operations, resulting in improved yields, reduced resource inputs, and enhanced profitability for farmers. (Intellias, 2023). Here are some key examples of successful AI applications and their impact on agricultural productivity (GeoPard Agriculture, n.d.):

- Precision Agriculture

AI-powered precision agriculture technologies enable farmers to optimize resource management by precisely targeting inputs such as water, fertilizers, and pesticides based on real-time data and predictive analytics. By utilizing sensors, drones, and satellite imagery coupled with machine learning algorithms, farmers can accurately assess soil conditions, monitor crop health, and identify areas of inefficiency within their fields. This targeted approach to farming not only maximizes crop yields but also minimizes waste and environmental impact, leading to improved productivity and sustainability.

- Crop Monitoring and Disease Detection.

AI-based crop monitoring systems leverage computer vision and image recognition algorithms to analyse visual data captured by drones or cameras installed in the fields. These systems can detect early signs of crop diseases, nutrient deficiencies, and pest infestations, allowing farmers to take timely corrective actions. By identifying and addressing potential threats to crop health at an early stage, AI-driven crop monitoring systems help prevent yield losses and ensure the overall health and productivity of agricultural crops.

- Predictive Analytics for Yield Forecasting

AI-powered predictive analytics tools utilize historical data, weather forecasts, and other relevant variables to forecast crop yields with a high degree of accuracy. By analysing past yield trends and correlating them with environmental factors, machine learning algorithms can generate predictive models that enable farmers to anticipate yield fluctuations and plan their operations accordingly. This proactive approach to yield forecasting empowers farmers to optimize harvest timing, logistics, and marketing strategies, ultimately maximizing profitability and reducing market volatility.

- Autonomous Farming Machinery

AI-driven autonomous farming machinery, such as robotic harvesters and precision planters, automate labour-intensive tasks in the field, significantly improving operational efficiency and productivity. These intelligent machines utilize advanced sensors, GPS technology, and machine learning algorithms to navigate fields, identify crops, and perform tasks with precision and accuracy. By reducing the need for manual labour and streamlining field operations, autonomous farming machinery helps farmers increase productivity, minimize labour costs, and optimize resource utilization.

- Soil Health Monitoring and Management

AI-based soil health monitoring systems leverage sensor technology and data analytics to assess soil quality, fertility, and moisture levels in real-time. By continuously monitoring soil conditions and analysing data collected from sensors installed in the field, these systems provide farmers with valuable insights into soil health and nutrient management. This information enables farmers to make data-driven decisions regarding fertilization, irrigation, and soil conservation practices, leading to improved soil health, enhanced crop yields, and long-term sustainability.

- Supply Chain Optimization

AI technologies are increasingly being used to optimize supply chain logistics and distribution processes in agriculture. By leveraging predictive analytics and machine learning algorithms, companies can forecast demand, optimize inventory levels, and streamline distribution routes, resulting in more efficient and cost-effective supply chain management. This enables farmers to deliver their products to market more effectively, reduce waste, and improve profitability.

AI technologies are driving a paradigm shift in agriculture, offering transformative solutions to address complex challenges and unlock new opportunities for innovation and growth. By harnessing the power of AI, farmers can optimize resource utilization, minimize risks, and enhance productivity, ultimately contributing to the advancement of sustainable and resilient food systems. As AI continues to evolve and mature, its integration into agriculture holds immense potential to revolutionize the way food is produced, distributed, and consumed, shaping the future of agriculture for generations to come. AI applications in agriculture have had a transformative impact on agricultural productivity, enabling farmers to make more informed decisions, optimize resource utilization, and adapt to changing environmental conditions. (Javaid, 2023). As AI technologies continue to evolve and become more accessible, their role in driving innovation and sustainability within the agricultural sector is expected to grow, ultimately shaping the future of food production and global food security.

## 7. Pedagogical Practices and Training

Addressing the digital literacy gap among agriculture workers is a multifaceted endeavour that requires comprehensive pedagogical approaches and robust training programs. In response to the increasing digitization of agricultural practices, there has been a growing recognition of the importance of equipping agriculture workers with the necessary digital skills and knowledge to navigate and leverage digital technologies effectively in their work. To this end, various pedagogical approaches and training initiatives have been developed to bridge the digital divide and empower agriculture workers to thrive in the modern agricultural workforce. (Gow, 2023).

One effective pedagogical approach involves the implementation of targeted training programs that focus on practical, hands-on learning experiences. These programs often incorporate a blend of classroom instruction, workshops, and field demonstrations to provide agriculture workers with tangible opportunities to learn and practice using digital tools and technologies. By immersing participants in real-world scenarios and providing guidance and support from experienced instructors, these training programs help agriculture workers develop the confidence and proficiency needed to embrace digital technologies such as farm management software, GPS-enabled equipment, and data analytics platforms. (O'Donoghue, 2018).

Moreover, integrating digital literacy training into existing agricultural education and extension programs is essential for ensuring that agriculture students and practitioners are adequately prepared to meet the demands of a technology-driven agricultural industry. By embedding digital literacy modules into curriculum offerings at agricultural colleges, vocational training centres, and extension programs, educators can ensure that learners acquire the fundamental digital skills and knowledge needed to succeed in their careers. These integrated approaches to digital literacy education provide learners with a solid foundation in digital literacy while also exposing them to the practical applications of digital technologies in agriculture. (FAO, 2023).

Collaborative learning initiatives and peer-to-peer knowledge sharing networks also play a crucial role in addressing the digital literacy gap among agriculture workers. By fostering a culture of collaboration and knowledge exchange within the agricultural community, these initiatives create opportunities for agriculture workers to learn from their peers, share best practices, and collectively build their digital literacy skills. Online forums, social media groups, and community workshops serve as valuable platforms for agriculture workers to connect, collaborate, and learn from one another, thereby strengthening their digital literacy skills and capacity to leverage digital technologies effectively in their work. (Molina, 2021).

Furthermore, mentorship programs can provide invaluable support and guidance to agriculture workers as they navigate the digital landscape. Pairing less digitally literate individuals with more experienced mentors who possess proficiency in digital technologies can accelerate the learning process and provide personalized assistance and encouragement. Mentorship programs can take various forms, including formal mentorship arrangements facilitated by agricultural organizations or informal peer mentoring relationships established within agricultural communities. By fostering mentorship opportunities, agriculture workers can gain valuable insights, receive tailored support, and develop the skills and confidence needed to embrace digital technologies in their agricultural practices. (Erazo, 2015).

Identifying best practices and successful training initiatives concerning AI in agriculture involves identifying programs that effectively address the unique challenges and opportunities presented by the integration of AI technologies into agricultural practices and the most recognizable are (ibid.):

- Tailored Training Programs

They are key to successful initiatives as they acknowledge the diverse needs and backgrounds of agriculture workers, offering a variety of training options such as workshops, seminars, online courses, and hands-on practical sessions. By providing flexible and accessible training opportunities, these programs ensure that agriculture workers can acquire the necessary AI skills and knowledge at their own pace and convenience.

- Collaboration and Partnerships

They are fundamental in successful training initiatives because these partnerships involve government agencies, agricultural organizations, educational institutions, technology companies, and industry experts. By leveraging the expertise and resources of multiple stakeholders, these initiatives offer comprehensive training programs covering various AI-related topics, from basic concepts to advanced applications.

- Experiential Learning

It is prioritized in effective training initiatives due to providing opportunities for participants to engage in real-world projects, case studies, and simulations that simulate agricultural scenarios and challenges. Through practical learning experiences, participants develop practical skills and confidence in using AI technologies, ensuring they can apply their knowledge effectively in their agricultural work.

- Continuous Learning and Support

An integral way to successful training initiatives which offer access to online forums, communities of practice, mentoring programs, and technical support channels for ongoing guidance and support beyond the initial training period. By fostering a culture of continuous learning and support, these initiatives empower agriculture workers to continuously improve their AI skills and stay updated on emerging trends.

- Outcome-Oriented Evaluation

An essential factor for assessing key performance indicators such as knowledge acquisition, skills development, behaviour change, and impact on agricultural productivity and sustainability. Through data collection and participant feedback, these initiatives identify areas for improvement and make informed decisions to enhance the quality and relevance of their training programs.

- Scalability and Sustainability

They develop scalable training models and resources that can be easily replicated and adapted to different contexts and regions. Moreover, they seek to build local capacity and institutionalize AI training within existing agricultural education and extension systems to ensure long-term sustainability and impact.

Addressing the digital literacy gap among agriculture workers requires a holistic approach that encompasses targeted training programs, integration of digital literacy into agricultural education and extension initiatives, collaborative learning initiatives, and mentorship programs. By equipping agriculture workers with the digital skills and knowledge needed to thrive in today's technology-driven agricultural landscape, these pedagogical approaches and training initiatives contribute to building a more digitally inclusive and resilient agricultural workforce, ultimately driving innovation, productivity, and sustainability in the agricultural sector. On the other hand, best practices and successful training initiatives concerning AI in agriculture emphasize tailored programs, collaboration and partnerships, experiential learning, continuous support, outcome-oriented evaluation, scalability, and sustainability. By adopting these principles and strategies, training initiatives can effectively equip agriculture workers with the AI skills and knowledge needed to drive innovation, productivity, and sustainability in the agricultural sector. (Gow, 2023).

## 8. Conclusions

The intersection of agriculture and technology is definitely multifaceted, particularly focusing on the integration of artificial intelligence (AI) in agricultural practices. Beginning with exploring Poland's agricultural policies the light was then shed on examining AI applications in farming, the transformative potential of technology in enhancing productivity, sustainability, and resilience within the agricultural sector.

Through initiatives such as precision farming, livestock management optimization, and supply chain innovation, AI is revolutionizing traditional farming methods and empowering farmers with advanced tools and insights. Moreover, Poland's commitment to research, innovation, and technology transfer underscores its dedication to driving agricultural advancement and addressing contemporary challenges such as climate change and market volatility.

When navigating into the evolving landscape of agriculture and technology, it's imperative to stay informed about the latest developments, policies, and initiatives shaping the sector. By embracing innovation, fostering collaboration, and prioritizing sustainability, stakeholders can harness the full potential of technology to build a more resilient, efficient, and inclusive agricultural ecosystem for generations to come.

# Review and analysis on AI, agriculture technology and farmer-driven innovations and best-practices on the field in Sweden

## 1. Agriculture Policies in the EU

The European Union (EU) has a comprehensive set of agriculture regulations in order to guarantee a steady supply of food, secure farmers' income, and preserve the environment. These policies are constantly evolving to address new challenges and opportunities, and they increasingly recognize the potential technology to transform the agricultural sector (EC,2022).

Common Agricultural Policy (CAP)

The Common Agricultural Policy (CAP) is the cornerstone of EU agriculture policy and has a cross-cutting objective on digitisation, knowledge and innovation which includes investment support for the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI). The latest CAP reform, which is in effect from 2023 to 2027, places a greater emphasis on sustainability and innovation and incorporate specific National Strategic Plans.

Sweden's Strategic Plan aims to increase the productivity, viability and competitiveness of the agricultural sector while protecting animal welfare and seeking increased ambition in environmental and climate standards. The strategy also aims to contribute to the development of Sweden's rural areas, to help ensure that these are attractive places to live and work in. The Plan is operating alongside national support schemes, national legislation and with the actions of the Recovery and Resilience Facility, namely the EUR 1.46 billion reserved for the green recovery. Sweden has prioritised the improvement of its knowledge and innovation system in the agriculture sector, with a particular focus on advisory services, knowledge sharing and upskilling. More than 43 000 persons are expected to receive advice, training and knowledge exchange, or participate in innovation groups, which will facilitate the introduction of new technologies and working methods in agriculture.

The Swedish Plan will take full advantage of high-speed broadband that will be brought to sparsely populated areas with the support of the RRF, the European Regional Development Fund (ERDF) and national measures. This will not only help with the implementation of innovative digital solutions but will also enhance the attractiveness of rural and sparsely populated areas.

## 2. AI Policies in the EU

The European Union (EU) has been at the forefront of developing policies and regulations on artificial intelligence (AI).

1. White Paper on Artificial Intelligence

In 2018, the European Commission published a *White Paper on Artificial Intelligence*, which set out a framework for the development and use of AI in the EU. The White Paper also called for the development of a new legal framework for AI in the EU.

2. *Regulation on Artificial Intelligence*

In 2021, the European Commission published a proposal for a *Regulation on Artificial Intelligence.* The proposed Regulation would prohibit the development and use of certain high-risk AI applications, such as AI systems that are used for social scoring or that could lead to significant harm to individuals. The proposed Regulation would also require certain AI systems to be subject to prior conformity assessment before they can be placed on the market or put into service.

3. EU AI Act

On Friday, 8 December 2023, the European Union (EU) institutions reached an agreement on the key terms and components of the Artificial Intelligence (AI) Act following months of intense negotiations. The AI Act is a landmark in global AI regulation, reflecting the EU's objective to lead the way in promoting a comprehensive legislative approach to support the trustworthy and responsible use of AI systems. The AI Act follows other major EU digital legislation, such as the General Data Protection Regulation (GDPR), the Digital Services Act, the Digital Markets Act, the Data Act, and the Cyber Resilience Act.

The AI Act is unifying how AI is regulated across the single market of the 27 EU Member States. It also has important extraterritorial implications, as it covers all AI systems impacting people in the EU, regardless of where systems are developed or deployed. Compliance obligations are significant, and largely determined by the level of risk the usage of an AI system poses to people's safety, security, or fundamental rights. Obligations apply along the AI value chain. The AI Act applies a tiered compliance framework. Most requirements fall upon the developers and deployers of AI systems classified as "high-risk", and on general-purpose AI systems (including foundation models and generative AI systems) posing "systemic risks". The agreement currently sets out a phased timeline for enforcement, starting with prohibited AI systems in 2025 and progressively extending to all AI systems by mid to late 2026. There are significant financial penalties for noncompliance.

It is important for business leaders in the EU and beyond to consider the implications of this complex legislation before it comes into effect. This consideration includes understanding how the AI Act interacts with existing and emerging rules and regulations in other jurisdictions, as well as with voluntary AI codes and principles. Businesses and other organizations should ensure they have an up-to-date inventory of the AI systems that they are developing or deploying. They will need to assess whether their systems are subject to compliance obligations and, if so, under which classification. Developers and deployers of high-risk and general-purpose AI systems will also need to ensure that effective AI governance frameworks and compliance systems are in place.

4. EU AI Pact

The AI Pact is a scheme that will foster early implementation of the measures foreseen by the AI Act. Companies will have the opportunity to demonstrate and share their commitment towards the objectives of the future AI Act and prepare early on to be ready for its implementation. More specifically, the Pact will encourage companies to voluntarily communicate the processes and practices they are putting in place to prepare for compliance and ensure that the design, development and use of AI is trustworthy:

- Commitments will take the form of pledges that will be published by the EU Commission.
- The AI Pact will convene key EU and non-EU industry actors to exchange best practices.
- Interested parties will meet in the first half of 2024 to collect ideas and best practices that could inspire future pledges.

In November 2023, the Commission has launched a "call for interest" for organisations willing to get actively involved in the AI Pact. As a next step, the Commission will bring together interested parties, in the first half of 2024, to discuss the ambitions of the Pact and collect preliminary ideas and best practices which could inspire future pledges. Following the formal adoption of the AI Act, the AI Pact will be officially launched and "frontrunner" organisations will be invited to make their first pledges public.

5. The European Data Act and common European agricultural data space

The Data Act aims to maximise the value of data in the economy by ensuring that a wider range of stakeholders gain control over their data and that more data is available for innovative use, while preserving incentives to invest in data generation. The data act should give the users of the connected products and related services the right to access data generated by those products and services. The Data Act entered into force on 11 January 2024, and it will become applicable in September 2025.

The common European agricultural data space will ensure that more data becomes available for use in our economy and society, while keeping companies and individuals who generate data in control. The objective of the agricultural data space is to develop a secure and trusted data space to allow the farming sector to share and access data, improving economic and environmental performance in the field. Production data, supplemented by publicly held data, presents new opportunities for monitoring and optimising the use of natural resources, and contributes to achieving the objectives of the Green Deal and the Common Agricultural Policy.

With the European data act, the European Commission is expected to support the implementation of a common European agricultural data space, facilitating the trustworthy sharing and pooling of agricultural data. The data space should increase the economic and environmental performance of the agricultural sector. This means enabling data sharing as well as practical, fair and clear rules on data use and access. In precision agriculture, internet of things (IoT) analytics of data from connected equipment can help farmers analyse real-time data like weather, temperature, moisture, prices or global positioning system (GPS) signals and provide insights on how to optimise and increase yield. This should improve farm planning and help farmers make decisions about the level of resources needed. It would also protect farmers that use smart agricultural equipment against manufacturers who would use insights into farm yields to speculate on agricultural commodity pricing, essentially using farmers' data against them (Panel for the Future of Science and Technology, 2023).

6. AI testing and experimentation facilities (TEF):

Together with Member States, the Commission is co-funding the TEFs to support AI developers to bring trustworthy AI to the market more efficiently and facilitate its uptake in Europe. TEFs are specialised large-scale reference sites open to all technology providers across Europe to test and experiment at scale state-of-the art AI solutions, including both soft-and hardware products and services, e.g. robots, in real-world environments.

These large-scale reference testing and experimentation facilities will offer a combination of physical and virtual facilities, in which technology providers can get support to test their latest AI-based soft-/hardware technologies in real-world environments. This will include support for full integration, testing and experimentation of latest AI-based technologies to solve issues/improve solutions in a given application sector, including validation and demonstration.

TEFs can also contribute to the implementation of the Artificial Intelligence Act by supporting regulatory sandboxes in cooperation with competent national authorities for supervised testing and experimentation.

## 3. Adaptation at National Contexts

Sweden has not yet adapted any EU regulation regarding artificial intelligence. The Swedish Government has stated that it welcomes the Commission's work to create a uniform regulation for AI within the EU and highlights that Sweden must be a leader in taking advantage of the opportunities that the use of AI can provide. The Swedish Government also supports the fact that the proposal is based on human rights, including the right to privacy, freedom of expression, non-discrimination and equality, but also personal integrity, protection of individuals regarding the processing of personal data and information and cybersecurity. Swedish authorities have also recognised the importance to prepare public administration in Sweden for the upcoming EU regulation, since a lack of clear governance and coordination in relation to the regulation could entail that Swedish public administration as a whole will be severely limited in its ability to use AI.

## 4. National Legislation Frameworks

The use of artificial intelligence (AI) in agriculture is growing rapidly in Sweden, as farmers seek to improve productivity and sustainability. However, Sweden's regulatory landscape for the use of AI in agriculture is shaped by a combination of general laws, specific regulations, and industry guidelines. While there is no overarching legislation specifically dedicated to AI in agriculture, several existing frameworks address relevant aspects of AI adoption and application in this sector.

1. Sweden, National Approach to AI (2018)

In May 2018, the Swedish Government released its national AI strategy National approach for artificial intelligence. This strategy points out the general direction for AI in Sweden in order to create a basis for future policy actions and priorities. In this sense, this strategy serves as a reference for the government to outline forthcoming policy initiatives with the aim to strengthen Sweden's welfare and competitiveness by means of AI. To this purpose, the Swedish strategy focuses on the following priority areas:

- Education and training;
- Research;
- Innovation and use;
- Framework and infrastructure.

In 2018, the Swedish Government set a goal for Sweden to become the global leader within innovation and the use of digital solutions. One of the technologies to achieve this goal is artificial intelligence ("AI"). The Swedish Government commissioned the Public Employment Services, the Swedish Companies Registration Office, the Agency for Digital Government, and the Swedish Tax Agency to promote the use of AI in public administration in 2021. The authorities' report on the assignment, which was published in January 2023, shows that a great demand to provide comprehensive and concrete support in developing and providing guidance for AI solutions has emerged in Sweden, not only in the business sector but also in public administration.

2. Committee directive: Enhanced AI capability in Sweden

On 7 December 2023, the Swedish Government decided to set up a Commission for Enhanced AI capability in Sweden through a Committee directive. This AI Commission will identify needs and propose measures that can help strengthen the development and use of artificial intelligence (AI) in Sweden in a sustainable and safe way. AI has great potential to contribute to increased innovation capacity, higher efficiency, and better competitiveness, but also to more efficient public administration. The purpose of the assignment is to ensure that Sweden, as a leading research nation, advanced industrial nation and ambitious welfare nation, better utilises the opportunities and manages the risks of AI, including helping to identify a niche in AI where Sweden can become an important partner for others.

3. Data Protection Law:

Sweden introduced one of the first data protection laws in the world in 1973 with the introduction of the Data Act (Datalagen). The supervisory authority Datainspektionen was founded the same year. On 1 January 2021, the name was changed to Integritetsskyddsmyndigheten ("IMY"). The GDPR is implemented by the statute Lagen (2018:218) med kompletterande bestämmelser till EU:s dataskyddsförordning. The unofficial English name for this statute is the Act containing supplementary provisions to the EU General Data Protection Regulation. This law is commonly refered to as "The Data Protection Act" (Dataskyddslagen).

4. Environmental Code

The purpose of the Environmental Code is to promote sustainable development. It is applicable to all persons and operators who undertake activities or measures which could impact on the fulfilment of the objectives of the Environmental Code. The scope of the Environmental Code is directly linked to the promotion of sustainable development. The Code is applicable to all activities or measures that are of significance for this purpose to be achieved. It therefore concerns all types of measures and operations that may be of importance to those interests the Code is intended to protect, regardless of whether they are part of a private individual's daily life or are some form of business activity.

Accordingly, AI systems used in agriculture may be subject to environmental regulations, particularly those related to water quality, pesticide use, and soil conservation. Developers and users of AI tools must ensure that their applications comply with environmental standards and minimize potential negative impacts on the environment.

5. Other frameworks

As stated above, Sweden has not yet enacted specific legislation governing artificial intelligence (AI). However, several existing laws and regulations may be applied to AI systems. These laws address issues such as (1) Ownership/protection[1]; (2) Antitrust/competition laws[2]; (3) corporate governance[3]

## 5. AI Technologies & Applications in Agriculture Industry

**Digitalisation and artificial intelligence for crop morphology measurements**

The shape and morphology of plants is related to variety, the underlying genetics and environmental factors (light, temperature, irrigation). Digital plant phenotyping refers to the use of computers for plant phenotyping where digital sensors are used to measure plant characteristics. One of the most common digital phenotyping methodologies is image analysis, where cameras are used to record images and software is used to automatically extract the measurements from the images to access plant morphology (the shape of a plant), in a reproducible and accurate way (Van der Heijden & Polder, 2015).

Currently, many different types of cameras are available for measuring important plant features to characterise plant morphology. The most used camera is the RGB colour camera, which produces images in the visible spectrum, mimicking the human eye. To relate the images to real dimensions, 3D information is often needed, which resulted in RGB camera-based 3D sensors. The Intel Realsense RGBD sensor is an affordable example of a RGB 3D sensor and is often used in horticultural phenotyping, e.g., for tomato fruit detection and counting (Afonso et al., 2020; Fonteijn et al., 2021).

Other examples are LiDAR sensors.

All of these might become low cost because of the development of smart phone cameras for consumers. In greenhouse crop production, the plants may be intertwined, and so they cannot be easily imaged from all sides. This leads to occlusion and hampers the possibility of imaging important plant traits with a 3D camera. To overcome this problem, more advanced imaging solutions are needed. This can either be achieved by a moving trolley system with a mounted camera, flying drones inside the greenhouse or a robot that scans the plant with a 3D camera from many viewpoints. Using

[1] Computer programs are literary works under the Computer Programs Directive 2009/24/EC, which has been incorporated in the Swedish Copyright Act (1960:729). However, in recital 11 of the Computer Programs Directive, it is stated that only the expression of a computer program is protected, and that ideas and principles are not protected by copyright.

[2] Competition law in Sweden is regulated by the Swedish Competition Act (2008:579), which, through Sweden's membership in the EU, is harmonised with the EU competition law, specifically Articles 101 and 102 of the Treaty on the Functioning of the European Union. Consequently, Swedish competition law is also interpreted in accordance with the European Court of Justice's case law.

[3] In Sweden, the central act regarding corporate governance is the Swedish Companies Act (2005:551). Furthermore, Swedish companies whose shares are listed on a regulated market in Sweden are obligated to apply the Swedish Corporate Governance Code and the regulated market's own rules and regulations. In addition to these, the Swedish Accounting Act (1999:1078), the Swedish Annual Accounts Act (1995:1554), the Swedish Securities Market Act (2007:528), and the Swedish Financial Instruments Trading Act (1991:980) are important regulations in the field of corporate governance. As the legislation is technology-neutral, there are opportunities and flexibility for the use of specific technical solutions in this field.

artificial intelligence algorithms, the point clouds from different single viewpoints are converted into a robust representation of the crop (Boogaard et al., 2020).

**Digitalisation and artificial intelligence for crop physiology performance**

Next to plant morphology, plant physiological processes are important for crop monitoring. In crop production, photosynthesis in the leaves yields important biochemicals, such as sugars, starch, chlorophyll and nutrients, that are transferred to the plant organs, flowers and fruits (Dieleman et al., 2018a). Therefore, measuring the efficiency of plant photosynthesis directly and non-destructively is a desirable way for obtaining information on crop performance and for the early detection of deviations from optimal physiological conditions. Technologies like chlorophyll fluorescence imaging and thermal imaging are promising, especially if they can be applied to other parts of crop canopies, as well as individual leaves. The chemical composition of the crop can be determined by sampling leaves or fruits, sending them to a laboratory and waiting for the analysis.

Recent imaging spectroscopy was tested on a laboratory scale, to determine the composition of biochemicals in crops, with promising results (Dieleman et al., 2018b). Imaging spectroscopy is an imaging technique for images taken using many narrow wavelength bands over a range extending across the visible spectrum (from ultraviolet to shortwave infrared) and compared to a standard camera, which only records red, green and blue light. In doing so, it creates an extremely detailed image of the reflection of light on plants or other objects. Imaging spectroscopy provides a lot of information on plant pigments, sugars, proteins, fats and water, as well as their distribution over the leaves or organs. Regions of interest, such as the fruits or leaves, can be automatically extracted from the image. This opens the possibility of using this technique on mobile platforms (Mishra et al., 2020).

Until now, most plant features could only be measured manually, destructively and/or very locally with scarce datapoints. Digitalisation of the measurement and use of modern sensors and camera systems will help to collect more datapoints. AI methods will largely help in the interpretation of variable data output. AI algorithms will also help to transform and combine the output of multiple sensors into useful information for growers.

**Data for autonomous growing and production**

Data regarding greenhouse production systems are becoming of increasing importance and are a means of deeper understanding and efficient management of the complex biological dynamic processes. Large and meaningful datasets about all growing aspects are sparse. The greenhouse climate is relatively well-monitored, resulting in a time series with short intervals. However, manual, subjective, time-consuming, often invasive, and costly measurements of traits of crop growth, development, pests, and pathogens result in fragmented weekly or bi-weekly data points (Bouzembrak et al., 2020). This implies considerable data uncertainty as a result of noise, missing data, inconsistent formats, and non-standard collection protocols, among others (Lezoche et al., 2020). Investment into integrating diverse and unstructured data is required before any additional meaningful insights are possible (Osinga et al., 2022).

Ongoing technological developments, computational power, and high-fidelity sensors offer new opportunities for automated, remote, and non-invasive sensing of growing parameters. The higher spatial and temporal resolution in the measurements and in the growing conditions allows for interpretation of the system's variability at coarser and granular levels and offers opportunities for sufficient information extraction towards more efficient adaptation of horticultural practices. AI and machine learning can deal with the larger datasets and capture the nonlinear relationships present in the heterogeneous data sources in greenhouses.

**Deep learning for pest and pathogen management**

In the future, the detection of plant pathogens and pests will become extremely important. Unless it is known what a plant is suffering from, nothing can be done about it. The earlier pests and pathogens are identified, the easier it is to control them. Automated systems are starting to play a greater part in this (Polder et al., 2014). Automatic detection of pathogens in plants, as early as possible and without damaging the plant, is an approach that is gaining ever more attention in horticulture. In automatic detection, the basic assumption is that a diseased plant looks different from a healthy one. For example, leaves can have subtle colour differences, which are often invisible to the human eye but can be captured using techniques such as spectral imaging. Spectral imaging, combined with deep learning techniques (described in the previous section), has the potential to become a powerful tool in pathogen detection in greenhouses and vertical farms. Pest detection is often challenging because pests and their eggs are often located underneath the plant canopy and are, therefore, difficult to detect. They are often very small and show a very local distribution. Crops in general might suffer from multiple pests at the same time. Therefore, not only high-resolution detection but also local and organism specific detection is required. High-resolution imaging, in combination with deep learning techniques might have the potential for precision farming in greenhouses and vertical farms. In both cases, large amounts of labelled images are required from different situations (locations, seasons, crop varieties) to sufficiently train the deep learning algorithms.

**Digital twins and decision support for market-oriented production**

Today's high-tech greenhouses are equipped with different standard sensors for monitoring light, temperature, humidity, and CO2 and for actively controlling different actuators (e.g. lighting, screening, heating, ventilation, cooling, CO2 dosing, fogging, dehumidification, irrigation, and fertiliser dosing) in order to control all growth factors important for crop production at every moment. Today's growers determine the climate, irrigation and crop management strategies based on experience and define the setpoints for climate and irrigation control manually. Actuators then operate based on the setpoints configured in a processing computer, while sensors give feedback on measured data for the control loop (Hemming et al., 2020). The rapid pace of technological advancements, AI, cloud computing, and the uptake of the IoT produces an increasing data stream at high spatial and temporal resolution, almost in real-time. In smart horticulture, the greenhouse grower can monitor and control operations at a distance, based on real-time digital information instead of direct observations and tasks on-site. Large amounts of data can be leveraged for the design and implementation of advanced models, known as digital twins. A digital twin is equivalent to real-life objects mirroring the behaviour and states over its lifetime in a virtual space (C. Verdouw et al., 2021). As a digital representation of actual physical systems and technology integrators, digital twins offer a solution for complex systems analysis and can act as decision support tools (Pylianidis et al., 2021). Digital twins are increasingly adopted in the manufacturing, automotive, and energy industries (Caputo et al., 2019).

**Crop health management**

Crop health management involves detection and actuation. Detection might be further enriched by prediction, but the extreme complexity of weeds, disease and pest dynamics has not resulted in many widespread commercial solutions yet. However, it is on the agenda of many corporations, such as Bayer, which has made large investments to develop prediction tools for mobile telephones (Digital Farming Bayer Global, 2022) since 2017. Smart actuation, by delivering an adjusted spray rate only to places where weeds are located, has recently seen successful solutions with a combination of artificial intelligence and computer vision (https://bluerivertechnology.com). The following examples provide a few representative cases of advanced machines for the delivery of crop protection products or the mechanical removal of weeds, but many more are on the way as new smart machines are continuously emerging.

**Planning by producer organisations or cooperatives**

Market forecasting, market demand fluctuates quite rapidly, which means that agri-food companies must be one step ahead to act in time. Facing this, companies have been pursuing predictive analytics techniques to improve their supply chains and optimise marketing operations. Due to its ability to effectively discover trends and patterns in large datasets, ML methods allow predictive analysis that can support not only agricultural operations, but also retail (Huber & Stuckenschmidt, 2020). Thus, considering financial constraints to make an accurate market demand forecast, and an automated inventory control system is a game changer for the retail sector. In addition, ML methods can also predict market prices and the tendencies regarding the agri-food sector that will be in the pipeline soon, by understanding the behaviour of market demand. With this, AI-based techniques have become very popular among producer organisations and cooperatives, to efficiently boost supply chain performance, increase productivity and profit, optimise stock management and resource allocation, reduce costs and waste and increase customer satisfaction.

**AI in soil and water management and irrigation**

Soil and water management has a number of new challenges. Climate change has made the weather more unpredictable and, therefore, forecasting is becoming more difficult. Periods with storms and high rainfall alternate with dry periods. More crop stress, caused by higher temperatures or by excessive rain or floods, is to be expected. Heat resistant varieties are one of the options but intelligent long term (longer than one growing season) water management is another necessity. During summers with high temperatures, flooding and the submergence of crops during longer periods can be detrimental. At the same time, temperatures are higher, and more droughts are expected; the crops need more water, either fed by rain or irrigation. Challenges from a crop growth perspective are important, but the role of the agricultural land in groundwater recharge and flood reduction also needs to be optimised as an ecosystem service to society. Using AI, we can combine real-time information from sensors, weather forecasts and crop soil modelling. In addition, spatial information from drones and satellites is accessible. In this way, climate adaptive management becomes feasible by taking into consideration the temporal and spatial variability of the soil and crop status in the field. It allows fast responses and reacts proactively to forecasts. Finally, AI decision support should be a combination of real-time sensors feeding data and imagery into crop growth and soil water balance models for the most optimal decisions. In general, the local level focusses on the farm and crop productivity, while the water resources require a regional dimension at the level of entire river basins and aquifers.

Co-funded by the European Union

National Initiatives:

**AI Sweden Start-up Programme (AI Sweden)**

The AI Sweden Start-up Programme is aimed at start-up who work with AI or who want to learn more about what AI could be used for. The programme consists of three stages, including learning, connecting, and accelerating. The learning stage included various types of learning content, including

courses, workshops, and seminars. The connect stage contain access to the AI Sweden start-up community. And finally, the accelerate step includes full AI Sweden partnership, project access, and engagement, as well access to the Data Factory and testbeds, among other things.

**The Data Factory (AI Sweden)**

The Data Factory is an initiative launched in 2019 by AI Sweden that supports their partner organisations by enabling them to bring their own challenges to receive support, as well as to take part in existing projects, or experiments in the available testbed environment. The goal of this initiative is to increase the speed of innovation and usage of AI in Sweden, and several projects connected to the Data Factory have already been launched. Some of these include the Road Data Lab which wants to integrate different types of data related to roads in order to add value beyond what any single dataset could provide, and SCAPIS AI platform which aims to create a secure research environment for use of AI on image data from SCAPIS (Swedish CardioPulmonary bioImage Study).

**Edge Learning Lab (AI Sweden)**

Edge Learning Lab is a testbed environment located in Gothenburg that enables developers, data scientists, researchers, students, and others to learn about edge learning, including its possibilities and limitations. Its purpose is to speed up the applied understanding of edge learning, including how to use and optimise it across industry, academia, and the public sector.

**Swedish AI Start-up Landscape (AI Sweden, RISE & Ignite Sweden)**

In 2020, the Swedish AI Start-up Landscape was launched as a joint initiative to pick out the best AI start-ups in Sweden to increase and contribute to the usage of AI while also making it easier for AI startups to access clients, capital, and talent. The chosen AI start-ups together form a landscape that acts as a quality stamp for them while simultaneously providing intel for the innovation ecosystem, investors, the government, and academia. Finally, the initiative is a part of the larger European AI Start-up Landscape which has the same goals but at the European level, and includes other partners such as the German Entrepreneurship, German Accelerator, appliedAI, and Hub France IA. As of 2022, Norway and the Netherlands have also joined the landscape.

## 6. Pedagogical Practices and Trainings

### 1. Artificial Intelligence' for the Agri & Food sector (NL AIC)

The Dutch AI Coalition (NL AIC) has developed the first AI course for the Agri and Food sector in collaboration with the Top Sector Agri & Food and Groenpact. A free online course that aims to give green entrepreneurs and green students a better understanding of the concept of Artificial Intelligence (AI) and its applications in the sector. The AI course for the Agri and Food sector consists of eleven interactive modules of 8 to 15 minutes with videos showing practical applications of AI in the sector.

The course takes about 2.5 hours in total and the modules consist of an alternation of lectures, videos and interactive elements. The course touches on topics such as big data, algorithms and machine learning and focuses on the question: how is all this applied within the industry?

2. Professional training and certification program (AI Farming Technology)

Certified Artificial Intelligence Farming Professional (CAIFP) is a training and certification program for candidates who are already working, want to start a new career or sustainable developer in the agricultural industry. This program does not require any programming or computer science expertise and is designed to introduce the basics to advance level of A.I. and agricultural jobs to anyone whether you have a technical or farming background or not. Each program exam is configured individually, with factors ranging from the following: (i) Number of Multiple Choices questions (50 to 70); (ii) Number of Short essay questions (3 to 5); (iii) Passing score (60%); (iv) Time limit (90 minute); (v) 30 hours of Farming Practice.

3. Artificial Intelligence for Agriculture Technology and Climate Change (Oxford University)

This course is for professionals in the agriculture, agri-tech, sustainability/climate change and food value chain sectors who aspire to be pioneers in the application of artificial intelligence (AI) in these domains. The philosophy of the course is based on applying AI techniques to specific problems in agriculture and climate change and exploring the broader impact of these technologies in the food value chain.

You will gain a unique understanding of applying AI to complex, interdisciplinary problems based on data. The course emphasises AI for Good, and AI with cyber-physical systems, i.e., AI with Edge, systems thinking, and design thinking.

# Review and analysis on AI, agriculture technology and farmer-driven innovations and best-practices on the field in Cyprus

## 1. Introduction

Cyprus is the third largest island in the Mediterranean, with a total area of 9251 $km^2$ and intense mediterranean climate.

The agricultural sector in Cyprus contributes around 1.65% to gross domestic product (GDP) in 2022. The main crop products are potatoes, citrus, vegetables, and grapes, whereas meat (pork, beef, poultry, sheep, and goat) and milk (cow, sheep, goat) are the most significant livestock products consumed. The main processed agricultural products are halloumi cheese with growing exports, followed by beverages such as "zivania" and local wines.

The main problems agriculture in Cyprus is facing, according to G.Adamides, are the prevalence of small and fragmented farm holdings, land degradation and water scarcity, the ageing of the rural population, the low education level of farmers, the lack of a skilled workforce, the high input costs (e.g., pesticides, fertilizers, irrigation), and various marketing and unfair trading practices. It is also projected that agriculture in Cyprus will be highly affected by climate change impacts, such as increased temperature and decreased precipitation. Furthermore, the Cypriot agricultural sector still lags in terms of the adoption of new smart farming technologies, as well as agriculture digitalisation in general, which is a strategic goal of the next programming period (2021–2027). Another problem Cyprus is facing, indicated from the validator of this report, is that due to the high temperatures Cyprus has, weeds have much more generations and Cypriot farmers must deal with larger populations of weeds harmful to the crops. This result to higher production costs, agricultural products with higher percentages of pesticides and the risk of weeds developing resistance to specific active substances.

Agri-tech offers the potential to mitigate against some of these challenges and future-proof the agricultural sector by using technologies to optimise yields and quality as well as more efficient resource use and less carbon footprint of the sector.

According to the Smart Specialisation Strategy of Cyprus, agriculture and livestock are dominated by small farms, with the average size being between 3 and 4 hectares, while 81% of them have less than €8,000 of standard output. In addition, the available land for agricultural use is in decline, falling from 166,000 hectares in 2005 to 112,000 hectares in 2016.

Most farms (97.6%) are family farms, with more than 50% of the regular labour being family members. Farmers are relatively old (only 3.3% of farmers are under 40 compared to 10% of EU-28), and the share (3.3%) of young farm managers aged below 40 is the lowest in EU (EU average 10.6%). Among the farmers, only 0.6% of them have full agricultural training. There is a lack of digital skills and awareness of the contemporary approaches to cultivation and the opportunities offered by technology to increase productivity and cost-based competitiveness. The low capacity of the sector to absorb new knowledge and adopt new methods and technologies is also reflected in the investments in agriculture, which are the lowest in the EU. The above limitations in agriculture keep productivity very low, at around 0.27%.

Due to the very low absorptive capacity and the absence of economies of scale in the agriculture sector, the local market of innovative Cypriot companies providing solutions for agriculture, such as precision agriculture, automation, and robotics, is very small.

Agricultural Research Institute (ARI) of the Ministry of Agriculture, Rural Development and Environment (MARDE) of Cyprus in their Interim Progress Report on ICT (Information Society in Rural Areas: Informing Farmers through new Information and Communication Technologies, November 2023) mentions ‘‘Continuous developments in technology prompt us to continue and strengthen research on the evaluation of the use of Smart Farming Technologies (SFTs) in main crops of Cyprus, conducting targeted experiments with based on the particularities and problems faced by Cypriot agriculture. It is considered necessary to write a new research proposal, within 2024, which will cover more broadly the SFTs issues and will be consistent with the Strategic Objective of the ARI, but also with the 2023-2025 Strategic Plan of the Ministry of Agriculture, Rural Development and Environment for the digitization of the rural sector. In this new proposal will also involve researchers from other branches of the ARI, thus following an integrated interdisciplinary approach.’’

Artificial Intelligence (AI) has already revolutionized many industries, from healthcare to finance, and now it is poised to do the same for agriculture.

There is a global competition among large countries like the USA, China, Russia, and UK to win the AI race. The EU, fully aware of the need to stay ahead in AI, has already announced a great number of AI projects to be funded. In the period 2021-2027 digital technologies in agriculture will continue to be a high priority of the European Union. In this context, the EU's Horizon Europe research program will provide € 10 billion for research and development in the food industry, agriculture, rural development, and bioeconomy.

## 2. Agriculture Policies in the EU

Agriculture is the only sector of the European Union (EU) where there is a common policy. EU agricultural policy covers a wide range of areas, including food quality, traceability, trade and promotion of EU farm products. It seeks to ensure a sustainable future for European farmers, provide more targeted support to smaller farms, and allow greater flexibility for EU countries to adapt measures to local conditions.

Initiated in 1962, EU’s Common Agricultural Policy (CAP) is a partnership between agriculture and society, and between Europe and its farmers aiming to:

1. support farmers and improve agricultural productivity, ensuring a stable supply of affordable food;
2. safeguard European Union farmers to make a reasonable living;
3. help tackle climate change and the sustainable management of natural resources;
4. maintain rural areas and landscapes across the EU;
5. keep the rural economy alive by promoting jobs in farming, agri-food industries and associated sectors.

In its most recent version (2023–27), CAP relies on Member States’ own strategic plans framed by 10 key objectives, which are:

1. to ensure a fair income for farmers;

2. to increase competitiveness;
3. to improve the position of farmers in the food chain;
4. climate change action;
5. environmental care;
6. to preserve landscapes and biodiversity;
7. to support generational renewal;
8. vibrant rural areas;
9. to protect food and health quality; and
10. fostering knowledge and innovation.

The CAP's main instruments include agricultural price supports, direct payments to farmers, supply controls, and border measures. Successive rounds of policy reforms in 2003, 2013, and up to the current version support the transition towards sustainable agriculture and forestry in the EU and requires farmers to comply more fully with environmental, animal welfare, food safety, and food-quality regulations to receive direct payments.

CAP 2023–27 builds upon the 2003 and 2013 reforms to provide Member States with greater autonomy over the application of CAP. Each Member State completed a national strategic plan that was subject to review and approval by the commission. This gave Member States greater flexibility to design and implement policies to address their unique needs and challenges while following the overarching principals and objectives of CAP.

The CAP 2023-27 is covered by three regulations, which generally apply since 1 January 2023:

- *Regulation (EU) 2021/2116*, repealing Regulation (EU) 1306/2013 (previous CAP 2014-20) on the financing, management and monitoring of the CAP;
- *Regulation (EU) 2021/2115*, establishing rules on support for national CAP strategic plans, and repealing Regulations (EU) 1305/2013 and 1307/2013 of previous CAP 2014-20;
- *Regulation (EU) 2021/2117*, amending Regulation (EU) 1308/2013 (previous CAP 2014-20) on the common organisation of the agricultural markets; Regulation (EU) No 1151/2012 on quality schemes for agricultural products; Regulation (EU) No 251/2014 on geographical indications for aromatised wine products; and Regulation (EU) No 228/2013 laying down measures for agriculture in the outermost regions of the EU.

For the years 2021-22, a transitional regulation (Regulation (EU) 2020/2220) was in force. The regulation laid down conditions for the provision of support from the European agricultural guarantee fund (EAGF) and European Agricultural Fund for Rural Development (EAFRD) during these years, extending and amending provisions set out in the preceding regulations. It remained in force until the new CAP began.

## 3. AI Policies in the EU

The use of Artificial Intelligence (AI) in the EU will be regulated by the *AI Act*, the world's first legislation on AI. With the growing influence of AI across various sectors, the EU, as part of its digital strategy, wants to regulate artificial intelligence seeks to strike a balance between fostering innovation and ensuring ethical and responsible AI development. AI can create many benefits, such as better healthcare; safer and cleaner transport; more efficient manufacturing; and cheaper and more sustainable energy.

The objectives of the EU AI Act are to create a regulatory framework for AI technologies, mitigate risks associated with AI systems, and establish clear guidelines for developers, users, and regulators. The act aims to ensure the responsible use of AI by protecting fundamental rights and promoting transparency in AI applications.

The legal framework for AI, has a clear, easy to understand approach, based on four different levels of risk: minimal risk, high risk, unacceptable risk, and specific transparency risk. It also introduces dedicated rules for general purpose AI models.

**Minimal risk:** Most of AI systems currently used or likely to be used in the EU fall into this category. Minimal risk applications can be developed and used subject to the existing legislation without additional legal obligations, as these systems present only minimal or no risk for citizens' rights or safety. Voluntarily, companies may choose to apply the requirements for trustworthy AI and adhere to voluntary codes of conduct.

**High-risk:** AI systems identified as high-risk will be required to comply with strict requirements, including risk-mitigation systems, high quality of data sets, logging of activity, detailed documentation, clear user information, human oversight, and a high level of robustness, accuracy and cybersecurity. Regulatory sandboxes will facilitate responsible innovation and the development of compliant AI systems.

Examples of such high-risk AI systems include certain critical infrastructures for instance in the fields of water, gas and electricity; medical devices; systems to determine access to educational institutions or for recruiting people; or certain systems used in the fields of law enforcement, border control, administration of justice and democratic processes. Moreover, biometric identification, categorisation and emotion recognition systems are also considered high-risk.

**Unacceptable risk:** AI systems considered a clear threat to the fundamental rights of people will be banned. It includes AI systems or applications that manipulate human behaviour to circumvent users' free will, such as toys using voice assistance encouraging dangerous behaviour of minors or systems that allow 'social scoring' by governments or companies, and certain applications of predictive policing. In addition, some uses of biometric systems will be prohibited, for example emotion recognition systems used at the workplace and some systems for categorising people or real time remote biometric identification for law enforcement purposes in publicly accessible spaces (with narrow exceptions).

**Specific transparency risk**: For certain AI systems specific transparency requirements are imposed, for example where there is a clear risk of manipulation, such as chatbots, users should be aware that they are interacting with a machine. Deep fakes and other AI generated content will have to be labelled as such, and users need to be informed when biometric categorisation or emotion recognition systems are being used. In addition, providers will have to design systems in a way that synthetic audio, video, text and images content is marked in a machine-readable format, and detectable as artificially generated or manipulated.

**General purpose AI:** The AI Act introduces dedicated rules for general purpose AI models that will ensure transparency along the value chain. For very powerful models that could pose systemic risks, there will be additional binding obligations related to managing risks and monitoring serious incidents, performing model evaluation and adversarial testing. These new obligations will be operationalised through codes of practices developed by industry, the scientific community, civil society and other stakeholders together with the Commission.

The regulations prohibit the following:
- Biometric categorisation systems that use sensitive characteristics such as political, religious, philosophical beliefs, sexual orientation, race.
- Untargeted scraping of facial images from the internet or CCTV footage to create facial recognition databases.
- Emotion recognition in the workplace and educational institutions.
- Social scoring based on social behaviour or personal characteristics.
- AI systems that manipulate human behaviour to circumvent their free will.
- AI used to exploit the vulnerabilities of people due to their age, disability, social or economic situation.

The final legislation is expected to go into force early this year (2024) and apply in 2026.

The proposed EU AI act's high-risk AI list does not explicitly mention AI applications in agriculture. However, it could be argued that several actual or foreseeable AI applications in agriculture would fall within the scope of that list, especially since that list is neither exhaustive nor fixed.

## 4. Adaptation at National Context

A *National Artificial Intelligence strategy of Cyprus* has been conducted in 2019 and approved by the Council of Ministers in 2020 with an implementation goal of 2026. According to the AI Strategy Report, Cyprus will focus on the following priority areas:

- Cultivating talent, skills and lifelong learning.
- Increasing the competitiveness of businesses through support initiatives towards research and innovation and maximising opportunities for networking and partnerships.
- Improving the quality of public services through the use of digital and AI-related applications.
- Creating national data areas.
- Developing ethical and reliable AI.

Cyprus has already established several Digital Innovation Hubs (DIHs) such as the CYRIC Digital Innovation Hub, the KIOS Innovation Hub, the Robotics Control and Decision Systems (RCDS) Lab at the University of Technology, and the Entrepreneurship Centre at the Cyprus University. These DIHs are active in various market segments (e.g. health, construction, transport, manufacturing, agriculture and energy) and in a wide range of technological areas, including AI, Big Data, cloud computing and cybersecurity.

In the *Cyprus Recovery and Resilience Plan 2021 – 2026* there are a series of projects regarding the use of Smart Agriculture technology.

The plan proposes "Specifically, the measures on primary sector focus on developing a competitive agriculture sector primarily through agri-tech and strong collaboration with business, higher-education institutions and research centres to excel. The measures regarding the secondary section focus on developing a competitive light manufacturing sector that includes production in areas of green-tech, agri-tech, etc.,"

The plan proposes investments specific to agriculture, but there are also investments planned for areas like water management that would have a direct effect on the sector.

To modernise and expand infrastructure supporting the agriculture, farming, horticulture, and aquaculture of Cyprus, the plan suggests reforms such as:

- Move agricultural practices from the 20th century to the 21st century by investing in a national centre for excellence in agri-tech.
- On-line, cloud-based platform for improving the trade and information in the fresh produce supply chain.
- Genetic Improvement of the sheep and goat population.

The main objectives aimed to be achieved through the reforms and investments are the following:

- To establish a centralised resource for best practices relating to agricultural/ agri-tech practices, animal husbandry and environmental protection.
- To improve the uniqueness, and competitiveness of the primary sector with aim of improving the yield, efficiency, and profitability of the sector.
- To build a close and active partnership between the farming community and universities, ultimately aiming to upskill and future-proof the community through alignment of curriculums, degrees, and graduates of local universities to the sector.

In the last years, Cyprus has introduced several initiatives to boost the agricultural sector in areas such as water and waste management, smart farming, environmental protection and new measures to ensure better animal welfare. But still, Cyprus agriculture practices are more 'traditional' with a limited implementation of 'Smart' practices with a small number of individual cases where Hydroponics and Aquaponics systems have been created (presented in Section 7 of this report) and the Research Stations of the Agricultural Research Institute (ARI) which are focused on experimental work.

## 5. National Legislation Frameworks

In line with EU priorities in digital transformation and following the EU's AI Act, the government of Cyprus will develop legislative framework to ensure the availability of data with transparent regulations, in particular on data protection. This legislative framework will consider EU directives on the free flow of data and general data protection and will facilitate the interoperability of data. To this purpose, it is important that the new legislative framework enables digital services to use up-to-date and high-quality information at the right moment, while taking into account the protection of personal data. With respect to ethics, the government of Cyprus is currently developing guidelines to ensure ethically sound and reliable developments in AI, i.e. by defining measures of transparency, responsibility, privacy, equality, diversity and safety among others. The developed guidelines should preserve human rights and social values. To coordinate the development of ethical guidelines, the Cyprian strategy advocates the creation of a National Committee on Ethical and Reliable AI. This

Committee will continuously and systematically monitor and analyse issues or problems related to the usage or development of AI technologies and provide recommendations for legal and ethical interventions. To successfully conduct this exercise, the Committee will take into account the Ethics Guidelines for Trustworthy Artificial Intelligence as prepared by the High-Level Expert Group on Artificial Intelligence. Cyprus is also active in developing international standards for AI to foster and facilitate industrial and economic developments in this field. The Cyprus Organisation for Standardisation (CYS) will establish a National Commission constituting of technical experts from the public and private sectors to monitor and evaluate the work of International and European Committees on AI. It will also be responsible to apply and introduce AI standards in all sectors of the economy of Cyprus.

The Common Agricultural Policy (CAP) of the European Union is implemented in Cyprus through the CAP Strategic Plan 2023-2027, which has been prepared by the Ministry of Agriculture, Rural Development and Environment (MARDE) and has been approved by the Council of Ministers and the European Commission.

The Cypriot CAP Plan will provide an opportunity to renew the agricultural potential of Cyprus, creating a robust primary sector. It aims to respond to the concerns of producers and consumers, to attract younger generations, maintain social cohesion and promote a sustainable rural development. In parallel, it intends to protect the environment in which farmers operate. The Plan will work with a view to shift towards a new agricultural model, which respects the use of natural resources and commits to preserving and improving them.

Cyprus aims to increase the sustainability and resilience of the agricultural sector by expanding the production of high-quality agricultural products while improving the economic viability of small and medium-sized holdings.

Cyprus will enable the set-up of a system for agricultural knowledge and innovation (AKIS) in order to promote innovation in the agri-food sector. The Cypriot Plan aims to provide relevant education and training to producers. It also foresees advice and cooperation to facilitate the transfer of knowledge and promote new technologies in the primary sector. Farmers may keep their farms modern and innovative, for example, by investing in digital technologies and/or by forming operational groups to develop innovative solutions and practices. In Cyprus there is a low share of farmers with vocational education in agriculture. According to the latest available data, 94.3% of the farmers registered as farm heads in Cyprus only have practical experience but have not received any vocational training. There is a need to focus more on entrepreneurship, rural economics, processing, and marketing.

No regulations, or any are foreseen in the future for the use of AI in agriculture, in Cyprus.

## 6. AI Technologies & Applications in Agriculture Industry

In the next years to come, the field of agriculture and especially the farming industry will play a key role in shaping everyone's lives. In today's agriculture, modern technology has played a huge part in the development of the agriculture industry, hi-tech systems such as robot, humidity, and temperature sensors, aerial imagery, and GPS-technology are constantly being used. These progressive technologies, along with precision farming and robotics, enable businesses to be more clean, efficient, profitable, and safer.

Some innovative farming methods and agriculture technologies that are playing a significant role in changing the agricultural sector along with their benefits are:

1. *Farm Automation:* Automation is already a major part of the farming process, but it will become even more important in the coming years. Farmers are already using drones to monitor their crops, and advanced sensors can tell them exactly when they need to water or fertilize their fields. These devices can also be used to monitor soil quality and ensure that crops aren't affected by drought or other environmental factors.
   The increased level of automation will allow farmers to focus more on other aspects of their business than traditional manual labour tasks like watering, seeding, and harvesting.
2. *IoT Technologies:* IoT is used as a smart farming solution for monitoring the crop field from anywhere. It involves using sensors to track soil moisture, crop health, livestock conditions, temperature, etc.
   IoT technologies make it possible to create automated irrigation structures where water resources can be managed efficiently. By collecting crop data such as moisture and temperature, IoT technologies can help determine the right amount of water for crops every season.
3. *Geographic Information Systems (GIS):* it relies on technology such as drones and satellites to understand crop position and types, fertilization level, soil status, and related information. With data generated from GIS remote sensing devices and software, farmers can determine the best location for crop planting in the field and make informed decisions on how to improve soil nutrition.
   In livestock rearing, GIS software monitors the movement of animals. This, in turn, will help farmers track animals' health, fertility, or nutrition.
4. *Blockchain technologies:* used to track plant information from the farms to the shelf. Powered by a decentralized database, this technology helps regulate the quality of food and its shelf life. The auditable database allows growers and marketers to monitor farm produce throughout the supply chain.
5. *AI/ ML & Data Science technology:* Agricultural forecasting is made easy when farmers deploy AI/ML & data science technology. The use of 3D laser scanning and spectral imaging/spectral analysis, for example, can help farmers predict weather scenarios and optimize the use of resources required for irrigation, fertilization, and pest control.
   Through AI/ML & data science technology, farmers can analyse their fields for the best locations for planting seeds. They can use computer vision to recognize plants' optimal height, width, and spacing. This data can then be used to optimize their growing methods.
6. *Controlled Environment Agriculture (CEA)*: is a method of cultivating plants in a fully regulated environment. It is also known as 'vertical farming or indoor farming.' In this type of cultivation, all the plant's needs are met by artificially providing them with water, nutrients, and light using hydroponic, aquaponic, and aeroponic techniques.
   CEA has proven to reduce some of the challenges faced in conventional farming. For example, it greatly reduces water consumption depending on the farm setup. In fact,

some vertical farms use 70% to 95% less water than what's typically required in traditional outdoor farms.
In addition to optimal water usage, CEA protects plants from adverse weather conditions and helps maximize the use of space for cultivation.

7. *Robotics:* The need to meet the increasing global food demand is one of the major driving forces for the wide application and adoption of agriculture robotics.
   Many farming activities performed by humans can now be done by agricultural robots (agribots), maximizing productivity and saving enormous resources. Today, agribots are used in seed planting, crop harvesting, weeding, sorting and packaging, livestock management, etc.
8. *Drones:* Drones are increasingly becoming useful in crop and livestock management. For example, farmers can use sensor-equipped drones to monitor the growth of plants, detect disease stress, monitor field temperature, and spray pesticides or fertilizers at desired locations on the field.
   In animal husbandry, drones are used to observe grasslands and track animal movements on big ranches. Some drones have thermal imaging cameras to detect sick animals with high body temperatures.
   The inherent benefits and the rise of drones in farm operations lie in their ability to help farmers acquire comprehensive data to make timely decisions.
9. *Precision Agriculture:* The increase in the global population has led to increased food production per capita. However, this has also led to water shortages due to irrigation purposes. To combat these issues, farmers are turning towards precision agriculture as it can save them both time and money.
   Precision agriculture is a rapidly evolving farm management system that involves the use of sensor technology, AI, GIS, and IoT to collect and analyse data about the soil, plants, and animals. It allows for more targeted use of inputs such as water, fertilizer, plant nutrients, pesticides, seeds, and labour. Precision agriculture deviates from conventional agriculture practices, where a uniform method is employed over a large area regardless of soil quality or topography variations.
10. *Big Data & Analytics:* The farm is becoming a data factory, with sensors and other technology collecting thousands of data points about everything from soil quality to humidity and crop yields. Big data & analytics can help farmers decide when to plant and harvest, how much water or fertilizer to use, and how much seed they should sow. Farming operations are subject to weather and environmental changes, which are difficult to access, especially for large farms. Applying big data and analytics in agriculture help farmers predict water cycles or rainfall patterns.
11. *Connectivity Technologies:* In today's information-driven world, agriculture production should be based on a knowledge- and data-driven approach. Farmers need to be able to communicate with each other, vendors, and customers to produce more food efficiently. This can be done through connectivity technologies.
    Connectivity technologies, such as mobile devices, satellite technology, and internet-based platforms, allow farmers to share information to make better decisions about

how they grow their crops or raise their livestock. These technologies also enable farmers to reach out to potential buyers or sell directly to consumers.

During 2010–2020, in Cypriot agriculture there were only two robotic applications, a semiautonomous agricultural robot sprayer used in two vineyard fields. Given that pesticides and fertilizers are widely used in agriculture to enhance crop protection and production, the use of robotics for targeted spraying in terms of climate-smart agriculture can lead to reduced pesticide application, thus improving sustainability and overcoming environmental concerns, as well as reducing material costs, human labour, and medical hazards. However, other robotic applications such as harvesting, which also involves a substantial labour cost, have not been examined in Cyprus. Also, no scientific works on robotic applications in animal production are reported, even though statistical data from the Department of Agriculture (DoA) of Cyprus show that such robotic systems (e.g., dairy robotic milking systems) do exist and are in operation in dairy cow farms in Cyprus.

Smart farming techniques and IoT technologies are applied in Cypriot agriculture. Cypriot farmers are learning to change their currently used farming techniques (e.g., water management, pest management) to respond suitably to the challenges of sustainability and climate change. Two pilot studies (CYSLOP and IoT4Potato) engage farmers, which supported the extraction of additional results, facilitated the identification of the best practices towards the large-scale realization of smart farming in Cyprus. These works offer opportunities for innovation in agriculture and climate change adaptation options and could help farmers to achieve sustainable optimization of agricultural production and reduce their ecological footprint. No scientific works were found in relation to IoT applications in animal production farms. This is even though 96 dairy cow farms use an automated electronic system for the detection of oestrus, as reported in DoA.

Similarly, to robotics and IoT, no remote sensing applications were found in the literature for animal production and climate-smart agriculture (CSA) technologies are applied to only certain crops.

There seems to be limited or no research works on ICT and digital farming, leading animal production farmers to find and apply such technologies on their own, thus creating a gap between scientific knowledge and practice.

In Cyprus, in recent years, there has been an increase in the use of hydroponics, especially in the greenhouse sector due to the promotion of hydroponics through the Rural Development Plan, but also due to its more efficient use of the rest of greenhouse equipment. However, hydroponics is still used to a limited extend and where it is applied, its potential is usually not fully exploited.

## 7. Pedagogical Practices and Trainings

The Agricultural Research Institute (ARI), a Department under the Ministry of Agriculture, Rural Development and Environment, of the Republic of Cyprus, is the foremost body for the evaluation, consolidation, improvement and maintenance of the genetic base of crop and livestock production in Cyprus.

ARI's research programs promote the National Strategy for Smart Specialisation in the field of agriculture and contribute to the reform and strengthening of the competitiveness of the rural economy. In 2014, it opened the Hydroponics Education Centre, offering Vocational Education to agriculture professionals.

The “Cyprus Agro Industry Center” (2020) organise 1-day theoretical and practical trainings about the basics of Hydroponics and Aquaponics.

On academic level, no specific training programmes have been found. The Institute of Professional Studies of UCLan Cyprus, in its Agriculture – Agribusiness course, in 2020 was offering a course in Hydroponics but currently it doesn’t exist on their module list.

**Best Practices in Cyprus:**

1. *CypruSaves:*

CypruSaves project was aiming to motivate farmers in using modern technology and tools, address current and future water shortages, and manage their cultivation in terms of soil, yield, nutrients, and pesticide use.

During the project, 10 Meteorological stations were installed and two gateways in vineyard fields, in Limassol and Paphos region, along with soil sensors for measuring soil moisture and electrical conductivity. Data were feeding the digital tools developed by the project for the estimation of water footprint and pests’ outbreaks for the benefit of local grape producers.

CypruSaves was one of 5 pilots/proposals, selected to join the H2020 DEMETER, an EU-funded project aiming at facilitating the deployment of inter-operable, data-driven and smart farming solutions. It was a consortium of 3 partners, Omnia and Zambartas wineries from Cyprus and Benaki Phytopathological Institute of Greece. The duration of the project was 1 year from May 2022 until May 2023.

2. *SPACE4GREEN – Trusted and GREEN traceability through EU Space technologies:*

SPACE4GREEN project aims to develop a technological solution that enables Trusted Digital Data Sharing. This solution will enable stakeholders to obtain automated certification for various activities, which means stakeholders will have irrefutable knowledge that a specific activity took place at a particular time and location, eliminating the need for human certification from a third party. By making it easier to verify that a specific activity is happening at a certain place and time, the project could help to improve food safety, sustainability, and transparency.

The project combines cutting-edge technologies, including Galileo OSNMA, Blockchain and a project-specific SDK. Satellite Technology Helps Farmers Monitor and Respond to Field Data. With Galileo OSNMA and Copernicus services, farmers can now monitor and respond to almost real-time data from their fields. Sensor technology detects crucial factors like water, nutrient, and pesticide levels, guiding farmers to deliver targeted solutions where they're needed most.

Earth Observation (EO) and accurate positioning are key to planning and monitoring sustainable agricultural practices and complying with the Common Agricultural Policy (CAP).

In Cyprus, the pilot vineyards of the CypruSaves project (mentioned above) are included as pilot case in SPACE4GREEN project.

The project is funded by Horizon 2020. It’s a consortium of 8 partners from 5 European countries. Coordinator is the Spanish company Integrasys and OMNIA is within the partners. The project started in November 2022 and is still ongoing.

3. *ECONUTRI - Innovative concepts and technologies for ECOlogically sustainable NUTRIent management in agriculture aiming to prevent, mitigate and eliminate pollution in soils, water, and air project:*

The general objective of the innovative project ECONUTRI is to optimize, validate, and demonstrate nature-based novel solutions adapted into a holistic concept, which contribute to reduction of nitrates and phosphorous leaching, control of nitrogen losses through ammonia volatilization, and mitigation of GHG emissions originating from the agricultural sector, including both plant and animal production. To achieve this objective, the project aims further to disseminate and scale up the application of these novel technologies, and support EU farmers and scientists through training and education to implement nature based nutrient management tools that would improve air, soil and water quality in Europe and China, and contribute to mitigation of global climate change. The Econutri project uses smart agriculture systems.

The project is funded by Horizon 2020. It's a consortium of 30 partners, 26 from Europe and 6 from China. Coordinator is the Agricultural University of Athens. Within the partners is the Agricultural Research Institute (ARI) of Cyprus. The project started in November 2022 and is still ongoing.

4. *IoT4Potato - Data-Driven Potato Production project:*

This project combines IoT technology with earth-surveying data, to help farmers reduce the cost of potato production and improve product quality, while at the same time reducing their environmental footprint. The project employs a network of telemetric IoT stations (agro-environmental stations called Gaiatrons through NEUROPUBLIC's gaiasense smart farming system), installed in potato fields to automatically collect atmospheric and soil data, which are combined with satellite data as well as information about agricultural activities provided by the producers themselves.

The use case innovation is offered as an inexpensive service with no technology related investment for end-users, making it accessible even to small farmers. Gaiatrons are specially designed to adopt to the operational requirements of the area they are installed in, ranging from a dense installation network under the canopy or large-scale deployment.

The aim of this use case's research activity was the support of potato production in Poland, Ukraine and Cyprus, three countries with significant tradition in potato production.

In Cyprus, two pilot fields located in Liopetri and Paralimni villages in Kokkinochoria area were chosen, due to the importance of the region in potato cultivation. One station was installed in each field.

The results indicate a potential reduction of up to 25% on water consumption, 15% on pesticides use and 19% on the total input costs. Furthermore, the experts agreed on the usefulness, ease of use, and the reliability of the gaiasense solution. Also, they identified the provision of real time and accurate data as well as the presentation of information with comprehensive tables and graphs, as the important features of the proposed smart farming system.

The project was a case study of the European program "Internet of Food and Farm 2020' (IoF2020) funded by Horizon 2020 (Horizon 2020 - Industrial Leadership). Coordinator was the Greek company Neuropublic in partnership with the Agricultural Institute of Research (ARI, Cyprus) and organizations from Poland (Delphy Poland and FFP2), Ukraine (AgroLV) and the Netherlands (Wageningen University & Research). The project started in January 2019 and completed in March 2021.

5. *CYSLOP - Digital Ecosystem Utilisation project:*

Another use case of the Internet of Food and Farm 2020 (IoF2020) project was the Digital Ecosystem Utilisation - (CYSLOP) that was aiming to demonstrate IoT solutions in vegetable farms in Cyprus and Slovenia. The use case objectives were i) to drive IoT uptake in countries where IoF2020 was not initially present, ii) prove the sustainability of those IoT interventions cost- and environmentally wise, and iii) unveil their potential for post-farm and/or consumer-oriented applications.

The selected pilot areas in Cyprus located in the mountainous Limassol district where the cultivations under study were aronia, goji berries and raspberries (four plots), and in coastal Ammochostos district with two plots of open-field strawberries and cherry tomatoes (under hydroponic cultivation).

The expected environmental, economic and social impacts involve efficiency improvement in terms of pesticide and water use reduction between 5 and 10%, respective cost reduction of 10%, reduction of farm visits by 20% and more than twenty newly deployed IoT devices. Last, by incorporating innovative traceability technology, this use case was among the first to integrate information from the entire food value chain (from farm to fork) to a marketplace, offering elaborate value propositions to users.

The coordinator of the project was the Greek company Future Intelligence (FINT) in partnership with organizations from Cyprus (Institute of Agricultural Research and University of Nicosia) and Slovenia (ITC Cluster). The project started in January 2019 and completed in March 2021.

6. *SmartFarmer – Improving skills for Smartfarming as an innovative tool for rural development and economic growth:*

This initiative was based greatly on adopting the principles and standards of smart specialization.

The main objectives of the SmartFarmer programme were to highlight the reasons for why the production and marketing of the superfoods is an alternative beneficial option for the bio-producers and the competitive advantages comparing to other bio-products.

The SmartFarmer project aimed to improve the skills and competences of people in the agricultural sector by introducing a training programme in five EU countries while at the same time encouraging rural development in project countries in particular and Europe in general. The project was based on the transfer of the results of ProudFarmer project that was completed in 2010 and provided innovative results that were successfully integrated in formal training programmes in partner countries. The objectives of SmartFarmer included the analysis of the MTTM training programme and materials, their adaptation to the requirements of the target group and project countries; sharing experiences in smart farming practices training and development of new e-learning contents; testing and evaluation; dissemination of information about the project and project results and preparation of appropriate mechanisms/processes for their further exploitation.

The SmartFarmer project has been recognized by the European Commission as a Good Practice Example and a Success Story.

The project has been implemented by a consortium of 7 partners from 5 EU countries. The Agricultural Research Institute was the project's Coordinator. Partners in the project were the Cyprus University of Technology, the Union “Farmers Parliament” (ZSA - Latvia), the Harokopion University of Athens (HUA - Greece), Greek Superfoods Cooperation (M.A.G.I.Efkapron - Greece), the Development and Innovation Network (RCDI - Portugal), and the Fundación Maimona (FM - Spain). The program was funded by the Foundation for the Management of European Lifelong Learning Programmes (IDEP) under the Leonardo Da Vinci Transfer of Innovation Program and ended in October 2015.

Few companies using smart farming technologies, including hydroponics are:

- Mountain Berries

A family business, established in 2018, with farms in the mountainous villages of Agridia, Chandria and Kyperounta with blackberries, blackcurrants, honeyberries, gooseberries, blueberries and many other colour raspberry variations. Mountain Berries were also implemented CYSLOP (above mentioned use case of IoF2020) meteorological and microclimatic data, developing smart farming and irrigation protocols for the reduction of expenditure and improvement in fruit quality.

- Vardakis Farm

Another family business located in Avgorou, at Kokkinochoria area. It cultivates strawberries and cherry tomatoes through hydroponic systems.

- HerbanLeaf Farms

A family start up business, located in Parekklisia, Limassol providing with better quality and healthier leafy greens and herbs using the latest sustainable farming techniques. Since 2017, they use hydroponic farming growing vertically in 40ft shipping container, that can produce the equivalent of 2 acres of land saving up to 95% of the water used in traditional farming.

- Planty Aeroponics Mediterranean Ltd.

Located in Psematismenos, Larnaca in January 2020 they launched the biggest horticultural greenhouse facilities and packaging factory in Cyprus suppling the market with premium horticultural and hydroponic products such as microleaves-microgreens, herbs and leafy vegetables, using the Nutrient Film Technique (NFT).

# Review and analysis on AI, agriculture technology and farmer-driven innovations and best-practices on the field in Greece

## 1. Agriculture Policies in the EU

Agriculture and the agricultural industry are a fairly small part of the EU's GDP, having an estimated gross value of €220.7 billion in 2022, which is accounts for about 1.4% of the EU's GDP in the same year, slightly more than the GDP of Greece in 2022 (Eurostat, Performance of the Agricultural Sector). However, multiple sources indicate that agriculture is at the heart of major EU strategies which have been developed to guide the EU towards a sustainable future. This is meant to be achieved through the use of its main policies as tools for a just transition as well as the promotion of sustainability and environmental protection in the next few years.

A summary of the main and current EU policies related to agriculture is presented in this chapter, with a focus on digitalisation and innovation within the agricultural sector, with AI applications integration also included.

### *Common Agricultural Policy (CAP) and European Green Deal*

The main policy within the EU that connects Europe, and its farmers is the Common Agricultural Policy (CAP), launched in 1962. Its main aims are to support farmers and improve agricultural productivity, to help European farmers have a sustainable income, to maintain rural areas within the EU and in more recent years, help in dealing with climate change and safekeeping the sustainable management of EU's natural resources. As is natural, the CAP has been evolving continuously to keep up with global trends and ever-changing new challenges that come up over the years.

The European Green Deal and the current EU agricultural policies are closely correlated as they both aim to promote sustainability and resilience, also within the agricultural sector. The European Green Deal addresses climate neutrality, biodiversity conservation, circular economy, sustainable food systems and digitalisation and innovation. As agriculture is central to the European Green Deal goals, the CAP is set to be a key tool that can drive the EU towards a sustainable future, with 40% of the CAP budget being climate relevant.

To this end, in December 2021, the formal adoption of the Common Agricultural Policy reform occurred (CAP 2023-2027), which entered into force on January 1st, 2023. This new CAP resulted in tailored national CAP Strategic Plans, designed by each EU country, which address ten specific objectives (European Commission, 2022). These objectives focus on, among others, environmental sustainability, climate change mitigation and adaptation, the increase of competitiveness through the fostering of knowledge and innovation and digitalisation. Although AI integration is not explicitly mentioned, the CAP encourages the adoption of innovative technologies to improve agricultural practices, AI applications being some of them.

### *EU Digitalisation within the European agricultural sector*

At the same time, the EU has been promoting the digitalisation of the European agricultural sector in order to increase efficiency, sustainability and competitiveness. In shaping the EU's digital future, there is emphasis given in the agriculture sector using latest technologies, including AI, in order for farmers to benefit in terms of sustainability, profitability and new perspectives in the way they work. Uses of such digital means include “data-sharing platforms and ecosystems needed for a common European agricultural data space” and “technologies to optimise water usage, accurately spread seeds and fertilisers, and reduce the need for harmful pesticides, among others” (European Commission, The Digitalisation of the European Agricultural Sector).

To bolster this initiative, the EU allocated more than €200 million for Research and Innovation (R&I) through Horizon 2020 for the development of digital technologies within the agricultural sector, including AI applications such as machine learning for crop monitoring, predictive analytics for pest control, or robotics for harvesting (European Commission, Digitalisation of the European Agricultural Sector, 2023). Horizon Europe (2021-2027) is also following this path, with EUR 10 billion to be invested in R&I related to food, bioeconomy, natural resources, agriculture, fisheries, aquaculture and environment. In terms of agriculture, emphasis is given to the integration of digital technologies and precision agriculture to improve farming practices and enhance efficiency.

### *EIP-AGRI and EU CAP Network*

The EU has also set up the EU CAP Network, in line with the Regulation of European Parliament and Council to support CAP Strategic Plans. The purpose of the CAP Network is to bring together different stakeholders (administrations, organizations, entrepreneurs, practitioners etc) with a goal of sharing knowledge about agriculture and rural policy. The EU CAP Network includes stakeholders from the Agricultural European Innovation Partnership (EIP-AGRI), which is a policy framework that contributes to sustainable farming while at the same time enhancing competitiveness and fostering innovation through the support of interactive innovation projects, hence promoting digitalisation and innovation in agriculture.

Based on the above and in order to enhance the interaction of different stakeholders, Agricultural Knowledge and Innovation Systems (AKIS) have been set up to support sustainable agricultural development through the dynamic promotion of innovation within the sector. Key components include, among others, a multi-level structure (European, national, regional and local levels), the active participation and involvement of farmers and farming organizations by contribution of practical knowledge and experience, networking and collaboration platforms as well as digitalisation and technology integration through digital platforms, smart farming applications and others.

### *Other policies related to agriculture*

There are also other policies and strategies that are also connected to the agricultural sector, as either complementary or part of wider strategies that keep agriculture in a key position. The Rural Development Policy is complementary to the CAP as it supports rural communities by strengthening the sustainability of rural areas environmentally, socially and economically. The Farm to Fork Strategy makes a significant part of the European Green Deal, and its main aim is to promote sustainable food production and consumption within the EU. Its targets of reducing pesticide use, promoting organic farming, and reducing food waste are also closely connected to agriculture, where in some cases, AI applications are also encouraged in order for these targets to be achieved.

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### *Conclusion*

While a small sector within the EU's GDP, in recent years, agriculture is increasingly of central and of crucial importance to wider EU strategies such as the European Green Deal. The reformed CAP aims to be a very useful tool towards the achievement of the European Green Deal goals as it addresses different aspects within it, from greening measures to biodiversity conservation and sustainable food consumption.

Given that the agricultural sector is embedded within these strategies, there are several policies that touch upon it, besides the CAP. As the EU is moving towards a digitalized era, it also encourages the agricultural sector stakeholders towards adopting digitalized and innovative practices, in line with the European Green Deal goals. Funds are being distributed towards not only innovative practices for farmers which also include AI applications, but also to the continuous and enhanced interaction of agricultural and farming stakeholders, in order to strengthen their interaction and exchange of knowledge and information.

## 2. AI Policies in the EU

### *Introduction*

In the evolving landscape of global technology, Artificial Intelligence (AI) stands as a cornerstone of innovation and progress, that facilitates life while presenting complex challenges. The European Union (EU) recognises AI's transformative potential for economic growth and societal progress, however, the EU recognizes the challenges, this is the reason for the acceleration of legislative procedures on institutional and national level. This document sets the stage for a broad exploration of the EU's approach and policies towards AI, highlighting their importance in the global technological race (European Commission, 2020).

The EU's historical engagement with AI has been marked by a philosophy that integrates innovation with a strong respect to ethical and societal values. This stance is reflected in the EU's leading role in the global discourse on AI, navigating through the complexities of technological advancements while ensuring alignment with fundamental human rights (European Parliament, 2020). However, the balance between AI prosperity aspects has to be regulated prioritising the protection of final beneficiaries, human beings and the society.

Regulatory Initiatives

The core part of the regulatory framework of the EU, and its ultimate goal, is to establish the AI Act, which is a draft EU law on Artificial Intelligence (AI Act)—the first of its kind in the world, quite promising and politically challenging. It applies to the development, deployment, and use of AI in the EU or when it will affect people in the EU. In addition, a solid risk methodology to define "high-risk" AI systems that pose significant risks to the health, safety, or fundamental rights of persons (Dervishaj, 2020).

The Act prohibits the placing on the market and putting into service of certain AI systems that materially manipulate human behaviour, whereby physical or psychological harms are likely to occur (European Commission, 2020).

On 09/12/2023, the Parliament and Council negotiators reached a provisional agreement on the Artificial Intelligence Act (European Parliament, 2023). The EU AI Act has cleared significant hurdles towards adoption, with representatives from each of the EU member states approving the proposed text on 2 February 2024. This approval sets the stage for the Act to be presented to the EU Parliament for final approval in the coming months, with expectations for it to become law by spring 2024. Following the political agreement reached in December, the final compromise text of the AI Act has been confirmed by Member State representatives, marking a crucial step towards its formal adoption. This development indicates a strong consensus among EU members and paves the way for the European Parliament's final vote on the text.

Once adopted, the AI Act will introduce a comprehensive framework for AI regulation in the EU, categorizing AI systems based on the level of risk they pose and establishing specific obligations for high-risk and general AI systems. Objectionable risk AI systems will be banned, while high-risk systems will be subject to stricter requirements. The Act also outlines obligations for providers of general-purpose AI systems, including transparency measures and steps to ensure content generated by AI is clearly identified.

The final steps towards the Act's adoption involve the European Parliament's vote on the compromise text, which is expected to be a formality given the broad support among EU Member States. Once the Act is adopted, it will officially enter into force 20 days after its publication in the EU's Official Journal, with a step-by-step implementation period for the new rules.

On the other hand, the AI PACT is a voluntary initiative developed in collaboration with the European Commission and major industry players, including Google. The pact aims to bridge the gap until the AI Act becomes fully enforceable by encouraging companies to adopt and adhere to responsible AI practices ahead of the legal requirements. It serves as a platform for organizations to demonstrate their commitment to ethical AI by making a regulatory security frame related to AI Act compliance and responsible AI use.

Moreover, the AI Pact is a voluntary commitment from organizations to align with the objectives of the upcoming AI Act and implement its measures before the formal deadlines (Reuters, 2023). In addition, it encourages early adoption of ethical AI practices, including risk assessments, data governance, and transparency measures and provides a framework for collaboration and sharing of best practices among EU and non-EU organizations to prepare for AI Act compliance (Trilateral Research, 2024).

The primary difference between the EU AI Act and the AI PACT lies in their nature and enforceability. The EU AI Act is a binding legislative framework that, once adopted, will be enforceable across all EU Member States, with specific obligations and penalties for non-compliance. In contrast, the AI PACT is a voluntary initiative that seeks to encourage proactive compliance and ethical AI practices ahead of the formal legislative requirements.

### *Foundational Principles of EU AI Policies*

The EU's AI policy framework is built on the twin pillars of fostering technological excellence and ensuring trustworthy AI. These principles intent to support a thriving digital economy that is ethically aligned and socially beneficial. Initiatives like Horizon Europe exemplify this approach, showcasing the

EU's commitment to innovation that is responsible and beneficial for society (European Commission, 2021).

The strategic deployment of AI across the EU's economic sectors is expected to generate significant productivity gains, driving growth and competitiveness in the global market. For example, the manufacturing sector is placed to transform through smart automation, predictive maintenance, and supply chain optimization, using AI to achieve new efficiencies (European Commission, 2021). Moreover, the EU's focus on digital innovation hubs stands as a testament to its commitment to promoting innovation ecosystems where SMEs can access advanced AI technologies and expertise (European Parliament, 2020). There is a growing interest in the applications of artificial intelligence (AI) in the agri-food sector, therefore, the EU Parliament published a policy study on 'Artificial intelligence in the agri-food sector: Applications, risks and impacts. The study examined among other issues the costumer protection, food safety and social policies related to the implementation of AI technologies (European Parliament, 2023).

The EU's ethical framework for AI, which emphasizes human oversight, transparency, and accountability, serves as a model for balancing technological advancement with societal values. This framework is critical in sectors where AI has profound implications for individual rights and societal norms, such as law enforcement and social welfare (Dervishaj, 2020). By prioritizing ethical AI, the EU is also exploring ways in which AI can contribute to social justice initiatives, providing a blueprint for leveraging technology in the service of the common good.

The White Paper on Artificial Intelligence, published in 2020, outlines the EU's ambition to excel in AI technology while maintaining a high standard of trustworthiness. This approach is critical for ensuring that AI development aligns with the broader digital strategy of the EU, aiming to enhance digital skills, data accessibility, and technological infrastructure (European Commission, 2020).

Recent policy developments have significantly influenced AI's role in the EU. The ongoing research and the integration of AI in addressing critical societal issues such as healthcare, climate change, agriculture, and transportation underscore the need for a dynamic and adaptive AI policy landscape. The future vision for the EU's AI policy could be seen as a harmonious integration of AI within society, coupled with continuous innovation and regulatory vigilance (European Parliament, 2020).

### *Conclusion*

The EU's AI policy has not a limited strategy but one that recognizes the importance of global collaboration. The EU actively engages in international forums to contribute to the global governance of AI, promoting standards that reflect its values and interests. This commitment to international dialogue is seen in its participation in organizations such as the Global Partnership on AI (GPAI), where it works alongside partners to foster the responsible development and use of AI (European Commission, 2020).

While the EU's approach to AI policy is noteworthy, it faces inherent challenges. Balancing innovation with regulation poses complex dilemmas, with privacy, surveillance, and global competitiveness at the forefront of policy considerations. The EU's strategic approach to AI policy, standing at the crossroads of innovation and responsibility, will be crucial in shaping the technological and ethical landscape of AI development. The ongoing dialogue among stakeholders is crucial for navigating the complex terrain of AI (Dervishaj, 2020).

## 3. Adaptation at National Context

In the era of modern technological advancements, Artificial Intelligence (AI) emerges as a top-level example of change and a significant disruptor across various sectors, with the potential to reshape industries with its profound capabilities. The adaptation of AI, however, is not uniform but influenced by the unique ecosystems of socio-economic, cultural, and political landscapes of individual nations. In Greece the strategic embrace of AI reflects a commitment to progress, while preserving the country's rich cultural heritage (OECD.AI, 2021a). This document explores the diverse strategies and challenges in the national adaptation of AI and also focuses briefly on the description of AI in the national context.

Since the beginning of the 2020s, the Hellenic Ministry of Digital Governance has been given attention to the creation of a national AI strategy (OECD.AI, 2021b). This process has been a collaborative approach involving major stakeholders in Greece, as well as experts from academia, and EU advisors, and it aims to position Greece at the forefront of the digital era.

### *Diverse Strategies in AI Adoption*

In a world where nations like the USA and China, driven by government support and private sector innovation, have set the pace and taken the lead in AI development, Greece is monitoring its own course within the EU's innovation-driven landscape. With the Generative AI Greece 2030 initiative, the nation is aspiring to launch its key sectors – agriculture, tourism, and maritime commerce – into a future sculpted by AI, fuelling growth and pioneering progress (Special Secretariat of Foresight, 2023).

### *Sector-Specific AI Implementation*

Healthcare, finance, agriculture, transportation, and public services are key sectors where AI's impact is evidently visible. For instance, in healthcare, AI-driven diagnostics and patient care models are revolutionizing treatments in many countries such as Germany and the UK. This demonstrates AI's transformative potential when aligned with national sector-specific needs. AI applications are among the top priorities for the agricultural sector, improving production results in the field, facilitating the work of the producers and maintaining the products for a longer period.

In Greece, where agriculture has been one the cornerstones of life for many generations, AI stands ready to revolutionise traditional farming practices (Ministry of Digital Governance, 2023). From precision agriculture powered by AI to sophisticated data analytics for optimizing supply chains, these innovations give hope of a revival for the agricultural sector. Moreover, linking AI with Greece's vibrant tourism and shipping sectors could redefine the country's economic landscape, enhancing experiences and efficiencies through intelligent systems.

### *Innovation and Research Ecosystem*

Greece's vision for AI is developed by the country's learning and research institutions. These knowledge hubs are crucial in organising AI innovations, forging alliances that transcend academia, industry, and government. The role of academic and research institutions is critical in national AI ecosystems. Collaborations between governments, universities, and the private sector in countries like South Korea and Canada have propelled forward AI research and innovation, setting benchmarks for others to follow.

In Greece the formation of a High-Level AI Committee, a move that clearly shows the strategic priority placed on AI, serves as a central point for these collaborative efforts (GSRI, 2024). Initiatives like the digital assistant for online government services represent the tangible benefits of this focus on AI (Ministry of Digital Governance, 2023).

### *Cultural Values and AI Policy*

Cultural values significantly influence AI adoption and policymaking. For example, Japan's approach to AI in eldercare reflects its societal norms and demographic challenges. Additionally, ethical frameworks vary, with countries like Sweden emphasising transparency and user control in AI applications (OECD.AI, 2021c).

Greece’s journey in AI is as much about technology as it is about people. Cultural values, the foundation of Greek society, cast a significant influence on AI adoption and policymaking. Ethical considerations, reflective of Greece's societal norms, are interlinked with AI strategies, ensuring that technological progress advances hand in hand with human-centric values.

### *Conclusion*

Emerging AI trends, such as advancements in machine learning and autonomous systems, will continue to impact national strategies. The adaptation of AI is predicted to accelerate, with increasing emphasis on sustainable and ethical AI development. Legislative initiatives, like the proposed AI regulations for distance learning and evaluation (exam), emphasize the nation's proactive stance in sculpting a regulatory framework helpful to ethical AI adoption (Kathimerini.gr).

AI adaptation brings a number of challenges interconnected with opportunities; therefore, it is a double-edged sword. As Greece deals with difficult ethical questions, privacy concerns, and the socio-economic impact of AI, it also stands to obtain the rewards of innovation and enhanced efficiency. The balance of these issues is crucial in the making of national strategies, which must be adaptive, ethical, and inclusive to harness the full spectrum of AI's potential.

Understanding diverse national approaches to AI is crucial in a globalised world. International collaboration and knowledge exchange will play a vital role in addressing the challenges of AI adaptation. As AI starts reshaping global landscapes, national strategies will need to be agile and responsive to technological advancements.

In the EU, Greece's commitment to AI is a dynamic highlight, symbolising both economic ambition and societal enrichment. The integration of national policies with EU legislation is central to this narrative, positioning Greece as a proactive contributor to the EU's digital future.

## 4. National Legislation Frameworks

Given that AI technologies are a fairly new topic that countries, including EU countries, increasingly rely on to facilitate several aspects of different sectors, steps have been taken in order to create legal frameworks which will safely integrate them to national policies while at the same time moving forward to effectively regulating them.

As previously mentioned, the EU has established the AI Act, which is a draft EU law on Artificial Intelligence, aiming to "ensure better conditions for the development and use of this innovative technology" (European Parliament Topics, 2023). In most EU countries, institutional frameworks regarding AI have been established and national strategies have been drafted up or are in the process of being drafted, which encompass applications in many different sectors. A common observation is that a significant number of countries have made provisions regarding different sectors such as education, health, economy, public governance etc., but few have specific provisions on agriculture. For example, France established a 5-year national AI strategy in 2018, revised in 2021, which promoted, among others, data sharing in agriculture by funding several data hub projects.

The emerging trend of AI use in different sectors led countries to create legal frameworks to regulate the development and utilization of relevant AI tools. In Greece, in terms of steps towards regulating AI technology development and use, on July 27, 2022, Law 4961/2022 was published in the Official Gazette, in which a national framework for regulating the use of AI technologies was introduced, for both public and private sectors. Law 4961/2022 sets up a framework to "ensure the rights of natural persons and legal entities, strengthening accountability and transparency in the use of artificial intelligence (AI) systems, and complementing the existing institutional framework for cybersecurity" (Data Guidance, 2023).

Through this law, which entered into force in March 2023, a Coordination Committee for AI was established in 2023, which is responsible for drafting the aforementioned National Strategy for AI and formulating AI policies through the establishment of key indicators on activities pertaining to AI. A Monitoring Committee was also introduced, aiming to ensure fair implementation, coordinate relevant authorities, and oversee its application. This specific legal framework that has been produced aims to establish "horizontal and vertical obligations" for both public and private bodies within Greece, while also providing guidelines which protect the rights of legal entities and natural persons and strengthening transparency and ethical use.

At the same time, a national strategy for AI is currently being developed since 2020, with the Greek Ministry of Digital Governance (MDG) taking steps towards integrating AI in different sectors involved in the digital transformation of the country. The National AI strategy is part of the main axes of the Bible of Digital Transformation Bible 2020-2025, which aims at transitioning the country to a future of digitalisation. The objectives include the determination of the conditions for the development of AI, the data policy as well as the development and use of AI technologies on an ethical basis. Different interventions and projects are already underway under the Bible of Digital Transformation, with 23 projects directly related to the digital transformation of the agricultural sector. While AI is again not specifically mentioned, it is understood that parts of these projects will also pertain to the use of AI in the agricultural sector.

However, in an ever-changing global environment where AI applications are continuously evolving, Greece is committed to continuing to shape the legal framework relating to these technologies, while the Greek Ministry of Digital Governance continues to spearhead the development of the National Strategy for AI. As Europe is embracing AI as a useful tool in almost all sectors of economy while also setting up a coherent framework to regulate it, Greece is following suit by committing to adapt relevant national policies which will address the challenges emerging from the development and implementation of AI technologies. The agricultural sector, which is a significant part of Greece's economy, does not seem to be prioritized over other sectors, it is however evident that any future legislative adjustments will include it in an all-encompassing legal framework.

## 5. AI Technologies & Applications in Agriculture Industry

### *Introduction*

The agricultural industry is a fundamental factor for the financial capacity of many states globally. Statistics show that agriculture contributed 4.3 percent of the share of economic sectors in the global gross domestic product (GDP) in 2021 (Statista, 2021). During global financial crises, funds tend to invest in land and agriculture. In past decades being a farmer was connected to hardship in the field, practicing the basics in agricultural activities and farming. However, the capacity of the practitioners in the field was reaching to the level of personal work and the actual outcome was depended also on weather conditions and other unexpected environmental changes.

The integration of Artificial Intelligence (AI) into agriculture is producing a revolution across the global agricultural landscape, introducing an era of efficiency and innovation previously unreachable. This transformation is evident on the size of farms of North America, the diverse agricultural lands of Europe, and the complicated in terms of landscape fields of Greece. Each region, with its distinct challenges and opportunities, discovers in AI an adaptable ally to improve traditional farming methods, giving a boost to the agricultural sector.

### *From global to local innovations in agriculture*

AI stands as a foundational pillar of modern agriculture worldwide, providing advanced solutions in crop surveillance, risk management, and resource allocation. Innovations such as self-operating tractors, AI-powered drones, and intelligent irrigation systems embody AI's significant influence (Ray, 2019). These technologies enhance operational efficiency and contribute to the sustainable farming movement by optimizing resource usage, thereby limiting the ecological impact (Smith, 2021).

AI’s influence is growing in European Agriculture. Europe's agricultural AI narrative is distinguished by a strong commitment to sustainability and accuracy. The EU's Common Agricultural Policy emphasizes the importance of AI’s integration to empower European agribusiness competitiveness while safeguarding the environment (European Commission, 2021). Nations like the Netherlands and Germany are at the forefront of AI deployment for greenhouse automation and animal farming, demonstrating AI's potential to increase productivity across varied agricultural situations (Van der Ploeg, 2020).

The Emergence of AI in Greek Agriculture is also worth noting. In Greece, where agriculture holds a central economic and cultural role, AI is starting to leave a significant mark. The nation's digital strategy aims to integrate AI across diverse agricultural practices, from the cultivation of olive groves to vineyards and fruit production. Initiatives in AI-assisted disease identification and accurate predictive signals foreseeing upcoming issues, as well as AI methods in longer maintenance of products and logistics, provide a potential to the development of Greek agriculture (Ministry of Digital Governance, 2023).

Co-funded by the European Union

### *Innovation in practice*

Sustainable farming is a critical aspect of AI in modern agriculture. AI aids in promoting sustainable practices by optimizing water usage and reducing the need for chemical fertilizers, thereby minimizing environmental impact (The Silicon Review, 2024). Also, precision agriculture has emerged as a key AI application, enabling farmers to manage their crops and soil more effectively. AI-powered drones and automated machinery facilitate efficient crop monitoring and harvesting. Additionally, remote sensing technology, through satellite imagery combined with AI analytics, provides critical insights into crop health and soil conditions (V7 Labs, 2023).

For instance, in the USA, AI-based soil analysis tools are helping farmers optimize fertilizer use (Think with Niche, 2024). These case studies demonstrate the practical benefits and flexibility of AI in agriculture. In the Netherlands, AI-driven greenhouse farming has significantly increased production, making a comparatively small country to produce enough for covering internal needs and exporting globally, making agricultural economy an important factor for financial development.

In addition, AI in animal farming introduced applications to monitoring animal health and behaviour, enhancing breeding, feeding, and disease prevention strategies. This not only improves animal welfare but also optimizes productivity of meat and dairy products, as well as reproduction.

### *Conclusion*

To sum up, AI is positioned to play a critical role in the future of agriculture. With the ongoing advancements in AI technology, the agricultural sector is set to become more efficient, sustainable, and productive (TYM, 2023), understanding these technologies and their applications is crucial in shaping the future of global agriculture. The development of AI solutions for the agri-industry will attract more capital for research and investments. However, the major challenge is how to connect and train the ordinary farmer to access and operate the new AI solutions for the field. In addition, the accessibility of AI technologies is still not affordable by small producers, as on the contrary, of big producers.

## 6. Pedagogical Practices and Trainings

In 2022, agriculture contributed around 3.76 percent to the GDP of Greece, which is slightly higher than in previous years (Statista, 2024). The Greek agricultural sector employs approximately 400,000 people and rural inhabitants represent about 31% of the Greek population, a number that is higher than the EU average. While unemployment especially in young ages remains an issue in the agricultural sector in Greece, the Greek CAP Plan pledges to follow the goals of the common agricultural policy, especially when it comes to shifting to digital agriculture. Innovation and new technologies are encouraged and promoted, while also focusing on young entrepreneurship and addressing digital literacy gaps.

### *Pedagogical approaches and training programs addressing the digital literacy gap among agriculture workers*

Aiming to keep up with the challenges of the transition to a digitalized agricultural sector, there are several pedagogical approaches and training programs that are being implemented to address the digital literacy gap among agriculture workers in Greece.

For example, the Lifelong Learning Centre of the Agricultural University of Athens regularly organizes such seminars and training programs which are specifically designed to cover topics such as precision farming, data management, agricultural drones and smart farming practices (KEDIVIM AUA). It also organizes, upskilling and retraining programs in high-demand industries with a focus on digital and green skills under the “Greece 2.0 – National Recovery and Resilience Plan”. These trainings include digital geospatial technologies (G.I.S., Drones, Satellite Images), geospatial technologies and Location Intelligence in Digital Agriculture, Technologies and advanced methods of control and traceability of agricultural products and food, etc.

There are often collaborations between public institutions, research or academic institutions and private sector stakeholders or industry partners with a purpose of designing training programs and educational resources on addressing digital literacy among agriculture workers. The Agricultural University of Athens is organizing such programs with different stakeholders from the private sector in order to provide high-quality educational materials relevant to the digital transformation of the agriculture sector for agriculture workers.

Agricultural extension services, including the Hellenic Agricultural Organization (ELGO) "DEMETER" and other Agricultural Cooperatives, also play an important role in providing training to farmers in Greece, with a focus on young farmers. They organize field demonstrations, on-farm training sessions, and training programs to promote digital literacy and adoption of digital tools in agriculture. Through these training programs, innovation and entrepreneurship are promoted in accordance with modern technological developments. Specialized knowledge is offered, so that farmers are able to cope with the demands of their profession, especially when integrating innovation and following developments of technology.

As well, there are several online resources and seminars that are offered by agricultural organizations and educational institutions, specifically webinars, e-learning modules and others, which contribute to bridging digital literacy gaps. Institutions such as the Agricultural University of Athens and the Agricultural university of Thessaloniki offer different webinars pertaining to digital upskilling of farmers. National and Kapodistrian University of Athens offers e-learning courses on the adoption of innovations in the agricultural sector as well as the digital transformation of agricultural enterprises through innovative practices and modern technologies.

### *Best practices and successful training initiatives*

Greece also has participated in EU-funded projects aimed at enhancing digital literacy and innovation in agriculture. Greece was part of the South-East Regional Cluster of the SmartAgriHubs project, which involves facilitating farmers’ access to “cutting edge ICT technologies tailored to farmers’ individual needs”. It also helped farmers access and use digital innovative applications which respond to their needs, all while building their capacities. IoF2020 (Internet of Food and Farm 2020) was a project focused on precision farming which involved Greek partners and provided training and support to farmers, researchers, and agri-tech startups. These projects facilitated knowledge exchange, technology transfer, and capacity building in digital agriculture.

Greece is also currently part of the Demeter project, which aims at adopting advances IoT technologies, AI applications and smart farming among others to lead European digital transformation in agriculture. The project is meant to help farmers by building on their already existing experience while at the same time focusing on digital information. As such, the Hellenic Agricultural Organisation

(ELGO) completed a full-day farming school under the Demeter project, where a number of farmers trained on a teaching farm in Central Macedonia, learning sustainable techniques from expert instructors. Topics covered were "integrated pest management, efficient irrigation, soil management, harvest and post-harvest management, animal husbandry, and agricultural machinery operation", showcasing a fine example of a best practice on addressing digital literacy among agriculture workers.

Another pedagogical approach could also be found in pilot agricultural projects. There are several pilot projects running in Greece, under either EU funds or other sources of funding, which focus on innovative methods of farming. Several pilot farms can be found in Greece, which focus on innovative methods of farming, such as regenerative farming (AgriCapture CO2 project, Regenerative Farms Greece). Other pilot farms focus on precision agriculture services where AI applications are of crucial importance (AgriBIT project). In these pilot projects, farmers could observe and learn more about applications of digital means, including AI, as these projects showcase innovative farming practices, such as sensor-based irrigation systems, precision fertilization, and crop monitoring using satellite imagery.

# Needs assessment surveys targeting agricultural workers and existing/ potential entrepreneurs

The Needs assessment survey was targeting agricultural workers, owners, experts and existing or potential entrepreneurs in order to identify current status, perceptions of staff and gaps in the use of AI applications and tools as well as explore potential ways to engage the agricultural workforce in utilizing these technologies.

The survey had been conducted with the participation of the four European countries of the consortium, Poland, Sweden, Cyprus, and Greece. The partnership had been requested to collect a minimum of 100 responses per each country. At the end of data collection, the partnership had received 431 responses in total.

## Methodology

In order to collect the appropriate data, both qualitative and quantitative data collection methods were used.

Quantitative research is expressed in numbers and graphs. It is used to test or confirm theories and assumptions. This type of research can be used to establish generalizable facts about a topic. (Streefkerk, 2019). Common quantitative methods include experiments, observations recorded as numbers, and surveys with closed-ended questions.

Qualitative research is expressed in words. It is used to understand concepts, thoughts or experiences. This type of research enables you to gather in-depth insights on topics that are not well understood. Common qualitative methods include interviews with open-ended questions, observations described in words, and literature reviews that explore concepts and theories. (ibid.)

The survey involved 4 main sections with 19 total questions. The first section of the survey included demographic questions, the second section involved specific information questions concerning the education level, the field and type of work, the access of information. The third section involved the digitalisation and AI use and the fourth section a summary.

- The demographic section included the following questions:
  1- Gender
  2- Age
  3- Town population

- The Specific Information section included the following:
  4- Education level
  5- Field of work
  6- Type of agricultural activities are you currently involved in or interested in pursuing as a potential entrepreneur?
  7- How do you access information and resources related to agriculture and entrepreneurship in your region?
  8- Would you say you stay updated on market trends, technological advancements, and best practices in agriculture?

- The Digitalisation and AI use section included the questions below:
  9- How familiar are you with the concept of artificial intelligence (AI) and its applications in agriculture.
  10- Have you personally used any AI-powered tools or technologies in your agricultural activities
  11- AI use
  12- What are the main challenges you face in adopting digital technologies, including AI, in your agricultural operations?
  13- Are you aware of any government initiatives or programs aimed at promoting digitalisation and AI adoption in agriculture?
  14- Do you believe that AI has the potential to improve efficiency and productivity in agricultural practices?
  15- Do you think AI can help in addressing environmental challenges, such as climate change and resource depletion, in agriculture?

- The Summary section included the following questions:
  16- Are there any challenges you face as an agricultural worker or aspiring entrepreneur in the agricultural sector?
  17- Do you think there is enough support available, such as funding and technical assistance, to help farmers and agricultural businesses adopt AI and digital technologies?
  18- Would you be interested in participating in training programs or workshops focused on AI and digital technologies in agriculture?
  19- Are there any additional comments or concerns you would like to share?

The following section provides the detailed results of the survey in each country.

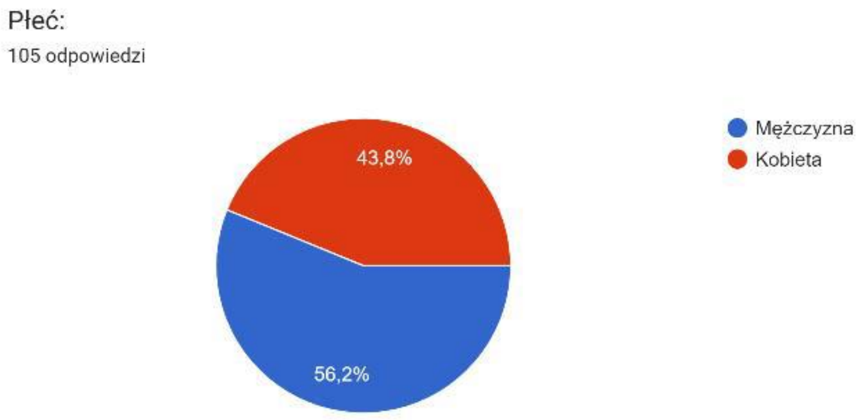
Needs assessment survey analysis in Poland

# Needs assessment survey analysis in Poland

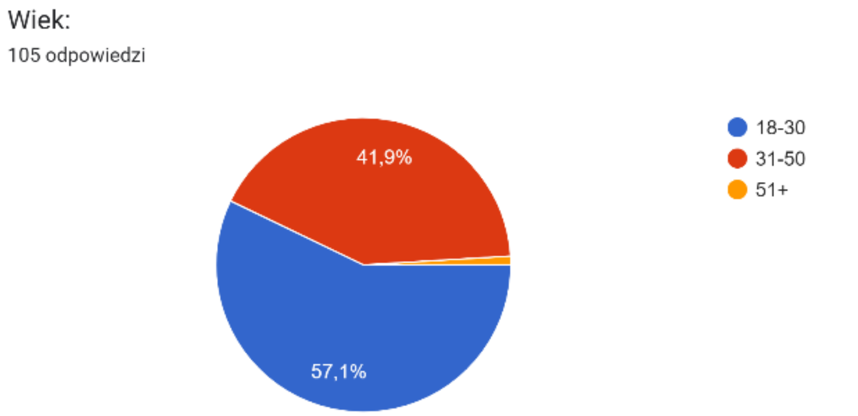
## 1. Results and discussion

The survey was carried out in April 2024 by distributing questionnaires among the local community, especially people connected with agriculture (owners, employees, experts) as well as potential agricultural entrepreneurs.

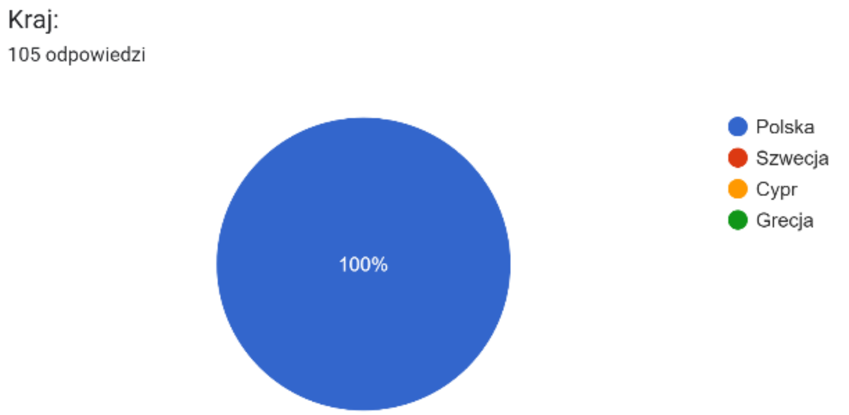
**Demographics**



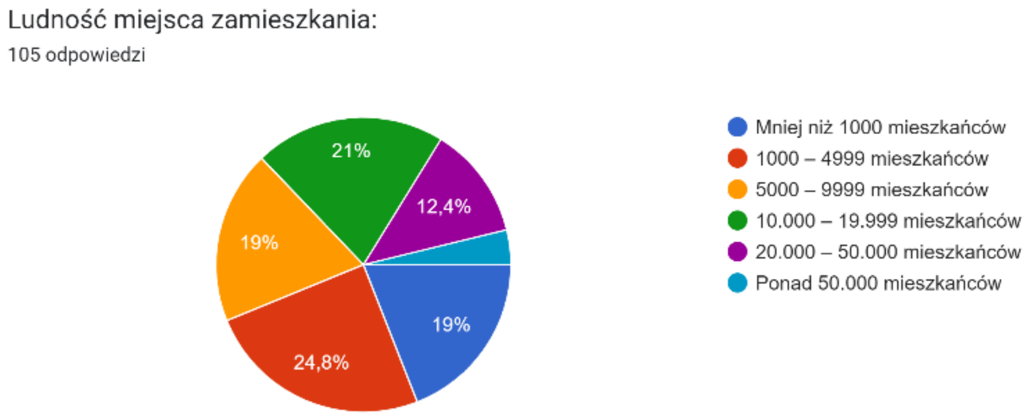

The diagram demonstrates the respondents' gender division as almost half and half. 46 of the respondents identified as female and 59 as men.




The diagram demonstrates that 57% of the respondents are between 18 and 30 years old and almost 42% are aged between 31 and 51. Only one person was aged over 51.

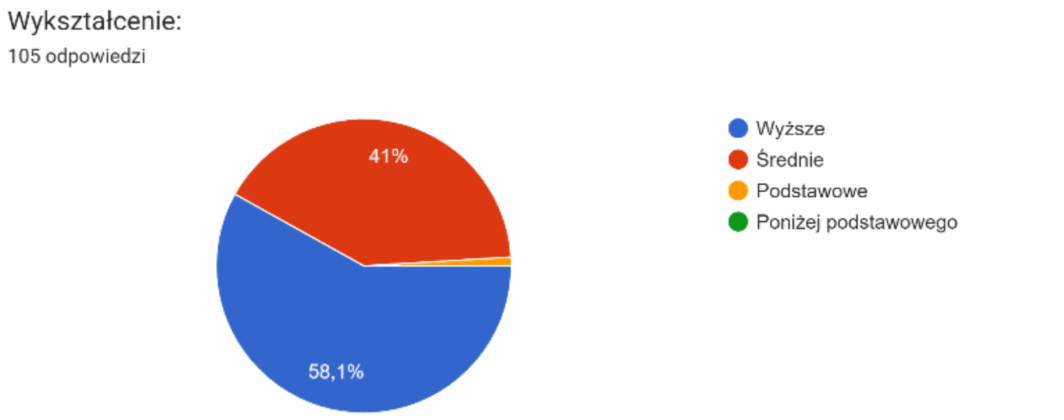



The diagram demonstrates that all of the participants of the survey were from Poland.

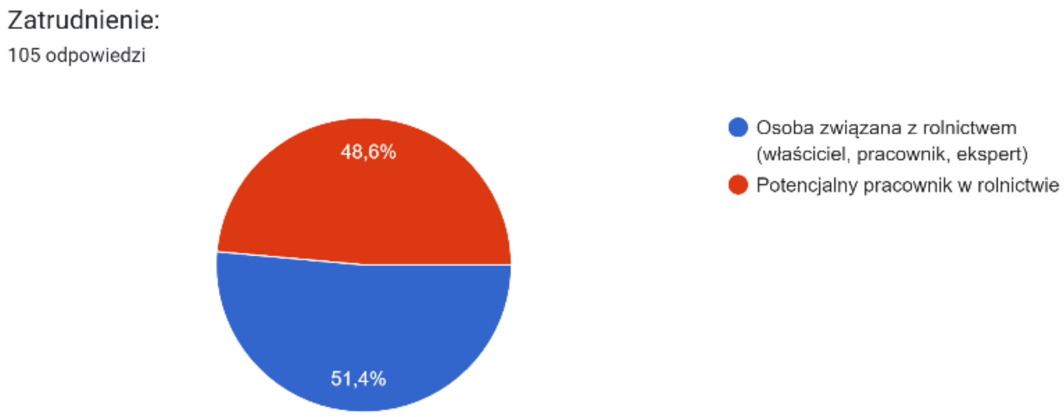



This question resulted in most varied answers in the section with almost 25% of respondents living in a place with population estimated at 1.000-4.999 inhabitants and 21% lives in a location with 10.000 – 19.999 inhabitants. The same percentage (19%) concerns both groups with 5.000-9.999 and with less than 1.000 inhabitants. 13 people stated that they live in a city of 20.000 – 50.000 inhabitants and only 4 people live in a city of over 50.000 inhabitants.

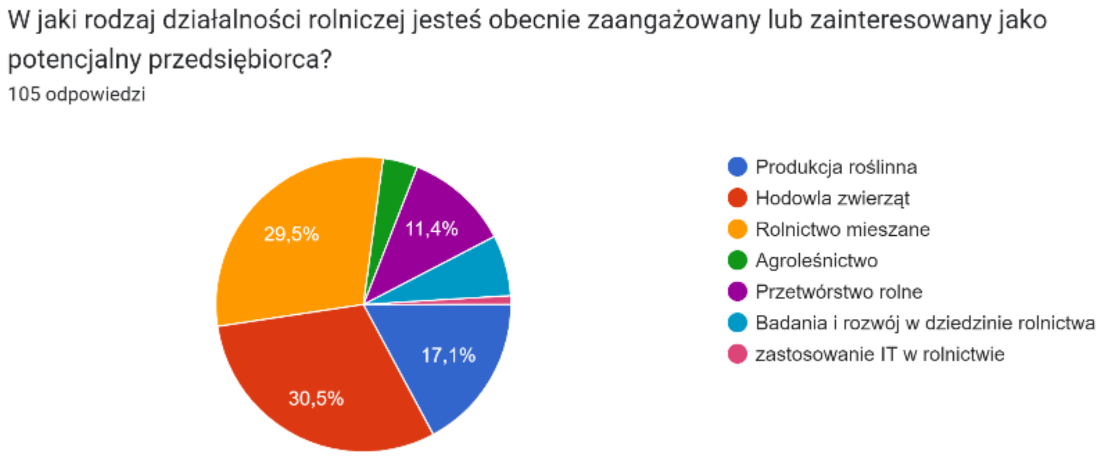
**Specific information**




The diagram demonstrates that 58% of the respondents graduated from a university and 41% got higher education. Only one person had education level lower than secondary school.

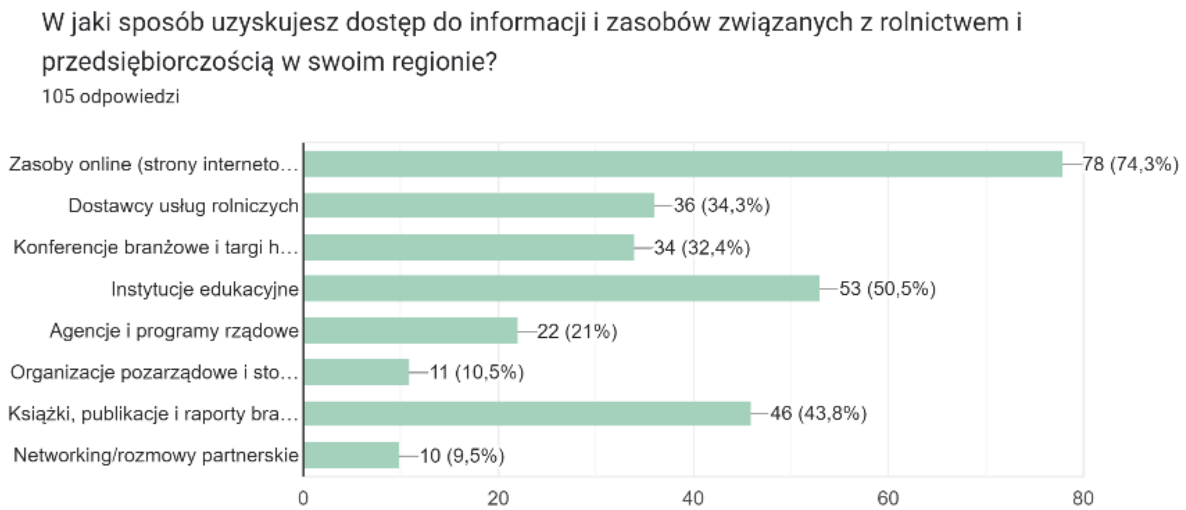



The diagram demonstrates that 54 respondents are connected to agriculture (owners, employees, experts) and 51 people are potential/future agrientrepreneurs.



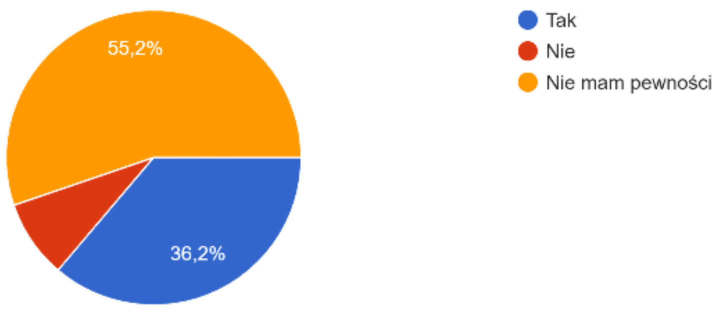

The diagram demonstrates a large variety in types of agricultural activities they are currently involved in or interested in pursuing as potential entrepreneurs.

The largest groups represent livestock farming (30.5%) and mixed farming (29.5%). Then 17% is represented by crop production and over 11% by agro-processing. The smallest numbers show in agricultural research and development (6.7%) and agroforestry (3.8%). There was also one person representing use of IT in agriculture.




The numbers in this questions show three major sources of accessing information and resources related to agriculture and entrepreneurship in the participants' regions being: online resources such as websites, forums, social media platforms (78 responses), educational institutions (53 responses), and books, publications, and industry reports (46 responses). Then, a total of almost 88% accesses information from agricultural service providers, industry conferences and trade shows, and government agencies and programs. Lastly, 20% of participants stated that they gain information from NGOs and industry associations as well as networking/peer conversations.

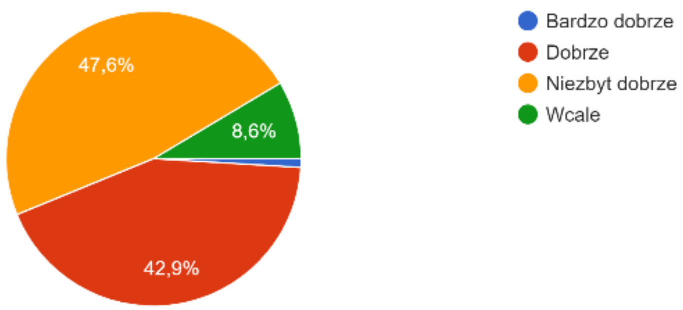
Czy powiedziałbyś, że jesteś na bieżąco z trendami rynkowymi, postępem technologicznym i najlepszymi praktykami w rolnictwie?
105 odpowiedzi




The diagram shows that over a half of the respondents stated that they are not sure if they are up to date with market trends, technological advancements, and best practices in agriculture. 38 people stated that they are surely updated well and 9 responded they are not up to date.

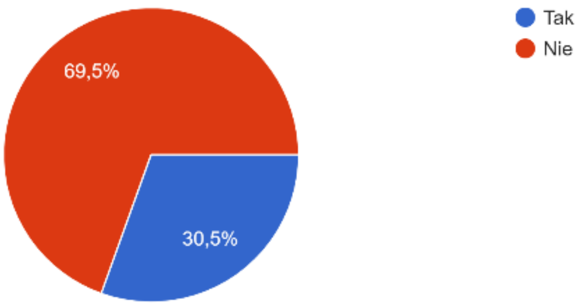
**Digitalisation and AI use**

Jak dobrze znasz koncepcję sztucznej inteligencji (AI) i jej zastosowania w rolnictwie?
105 odpowiedzi



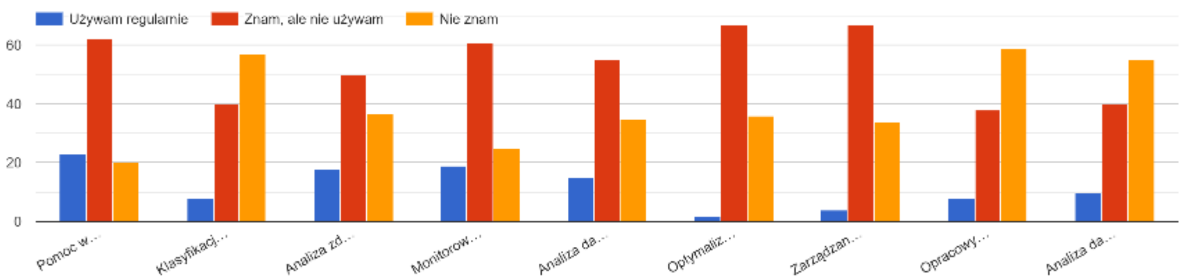

Over half of the respondents stated that they are not well (47.6%) or not at all (8.6%) familiar with the concept of artificial intelligence (AI) and its applications in agriculture. Roughly 43% are familiar and only one person is well oriented in the topic.

Czy osobiście korzystałeś z narzędzi lub technologii opartych na sztucznej inteligencji w swojej działalności rolniczej?
105 odpowiedzi




Almost 70% of the participants stated that they haven't personally used any AI-powered tools or technologies in their agricultural activities. 30.5% responded that they used it personally.

Wykorzystanie AI:

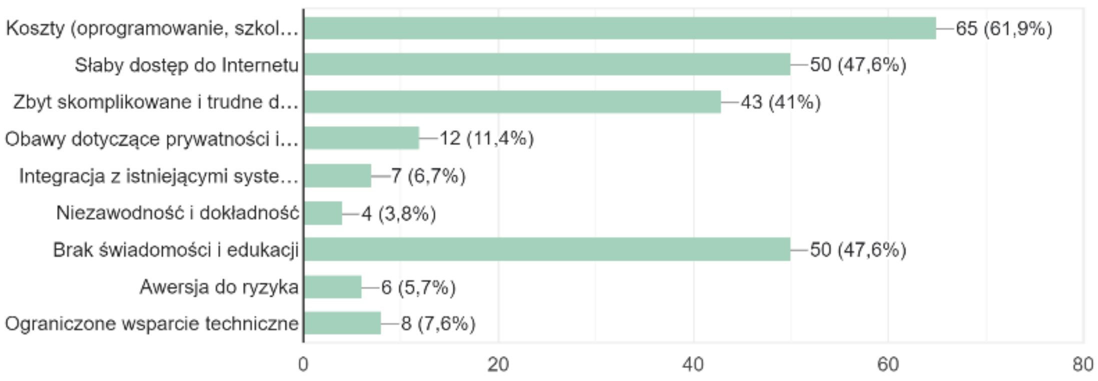



Regarding the use of AI, most of the sentences were rated as "I know about it but do not use it".

*Assistance in predicting crop yields based on weather data and historical trends* is used by 23 of our participants, 62 of them know it but do not use, and 20 do not know it at all. *Classifying and identifying weeds in agricultural fields* is used by 8 of our participants, 40 of them know it but do not use, and 57 do not know it at all. *Analysis of satellite imagery to detect crop health issues* is used by 18 of our participants, 50 of them know it but do not use, and 37 do not know it at all. *Monitoring livestock health and behaviour* is used by 19 of our participants, 61 of them know it but do not use, and 25 do not know it at all. *Analysing soil data to recommend optimal crop planting strategies* is used by 15 of our participants, 55 of them know it but do not use, and 35 do not know it at all. *Optimising supply chain logistics for agricultural products* is used by 2 of our participants, 67 of them know it but do not use, and 36 do not know it at all. *Managing and optimizing energy usage on farms* is used by 4 of our participants, 67 of them know it but do not use, and 34 do not know it at all. *Development of predictive models for disease outbreaks in crops or livestock* is used by 8 of our participants, 38 of them know it but do not use, and 59 do not know it at all. *Analysing historical data to optimize crop rotation practice* is used by 10 of our participants, 40 of them know it but do not use, and 55 do not know it at all.

Jakie są główne wyzwania związane z wdrażaniem technologii cyfrowych, w tym sztucznej inteligencji, w działalności rolniczej?

105 odpowiedzi

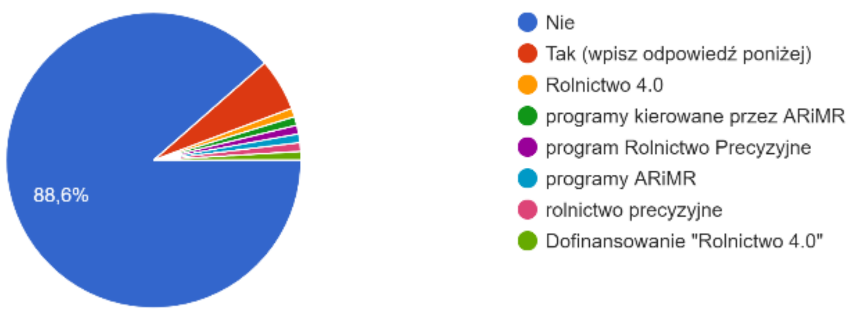



Regarding the main challenges that the participants face in adopting digital technologies, including AI, in their agricultural operations, most of the respondents (62%) stated that it is caused by costs (software, training, infrastructure).

A 100 people voted for poor Internet access (47.6%) and lack of awareness and education (47.6%). Next in line was "Too complex and hard to understand" (41%). The lower rates were given to: Data privacy and security concerns (11.4%), limited technical support (7.6%), integration with existing systems (6.7%), risk aversion (5.7%), and reliability and accuracy (3.8%).

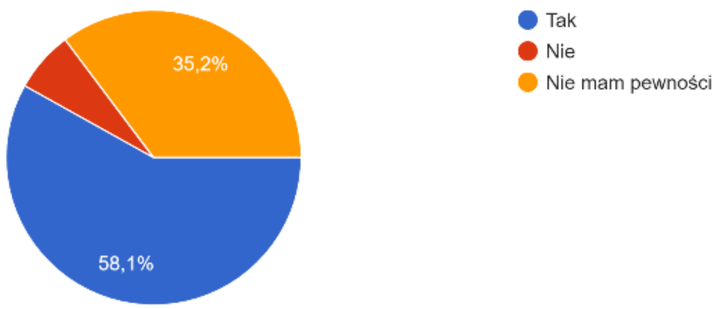
Czy znasz jakieś inicjatywy lub programy rządowe mające na celu promowanie cyfryzacji i wdrażania sztucznej inteligencji w rolnictwie?

105 odpowiedzi



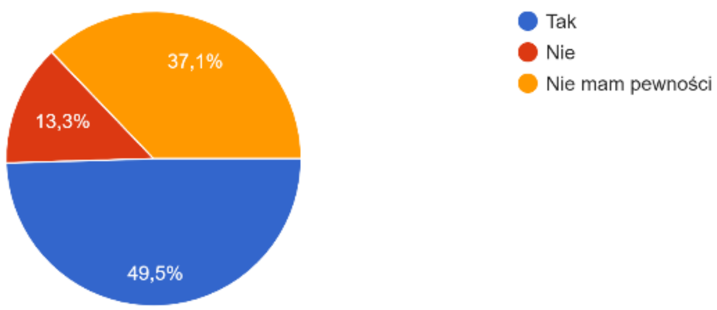

In the question "Are you aware of any government initiatives or programs aimed at promoting digitalisation and AI adoption in agriculture?" most of the participants (88.6%) responded that they are not aware of any initiatives of this type. Only six respondents (5.7%) pointed at specific programmes which were: agriculture 4.0, precision agriculture, and lastly programmes managed by the Agricultural Restructuring and Modernisation Agency.

Czy uważasz, że sztuczna inteligencja ma potencjał do poprawy wydajności i produktywności w praktykach rolniczych?
105 odpowiedzi




Over half of the respondents (58.1%) stated that they believe that AI has the potential to improve efficiency and productivity in agricultural practices. Only 6.7% didn't agree, and the rest of the group (35.2%) was not sure.

Czy uważasz, że sztuczna inteligencja może pomóc w sprostaniu wyzwaniom środowiskowym, takim jak zmiany klimatu i wyczerpywanie się zasobów w rolnictwie?
105 odpowiedzi



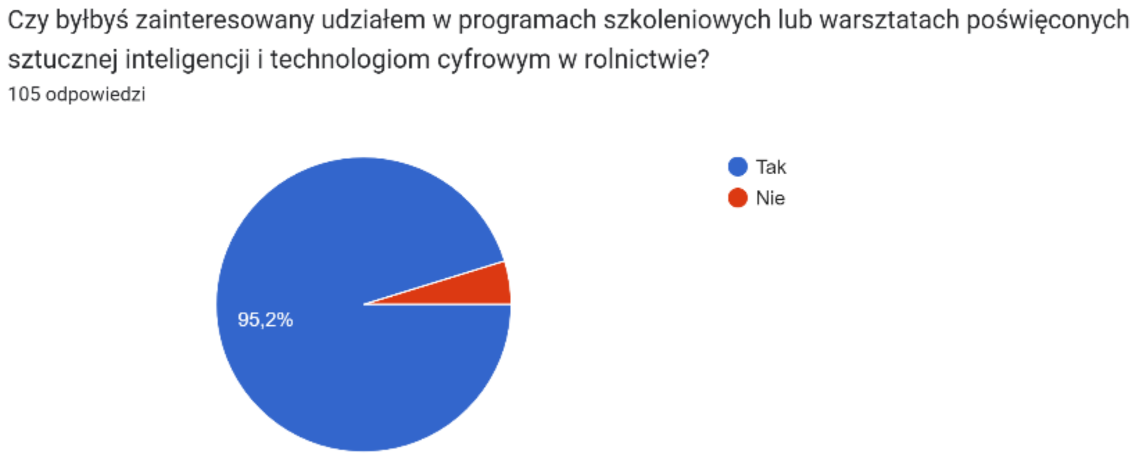

Nearly half of the respondents (49.5%) stated that they think AI can help in addressing environmental challenges, such as climate change and resource depletion, in agriculture. As much as 13.3% didn't agree with this, while 37.1% were not sure.

**Summary**

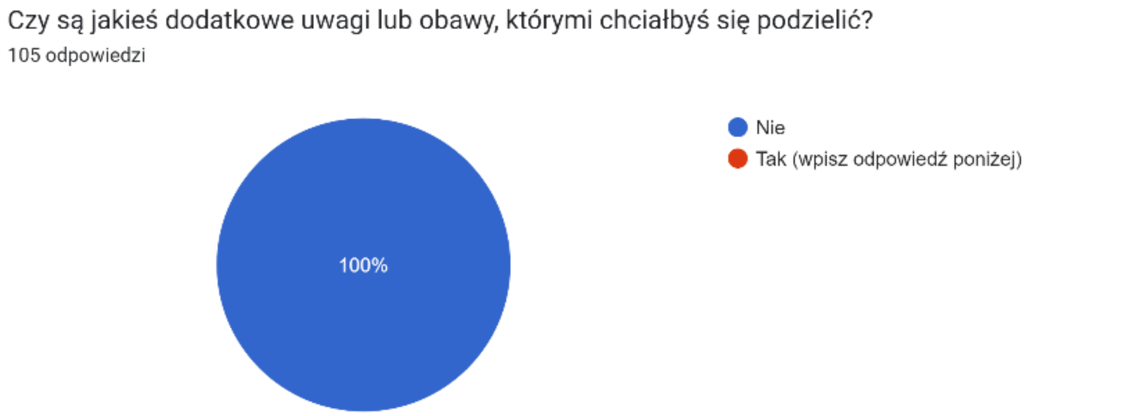

Regarding the challenges participants face as agricultural workers or aspiring entrepreneurs in the agricultural sector, most of the respondents (80%) stated that there do not face any.

The remaining 20% pointed at: profitability of production, administrative difficulties, reliability or integration of equipment, lack of explanation in the delivery of new EU aid schemes, droughts, forest animals, energy prices, competition, changing demands, difficulty in selling crops, concerns about privacy, prices of products, fear for one's privacy, gaining access to the web, uncertainty of the industry, too much bureaucracy for officials, prices, red tape for authorities, bureaucratisation.


The votes in the question regarding enough support being available, such as funding and technical assistance, to help farmers and agricultural businesses adopt AI and digital technologies, the votes were divided. Most of the participants (48.6%) didn’t agree with this statement and only 4.8% stated that the support is enough. The remaining 46.7% were not sure.




The question regarding being interested in participating in training programs or workshops focused on AI and digital technologies in agriculture was received rather positively as almost all of the respondents (95.2%) stated that they would like to participate in such initiatives. Only 5 people were not sharing interested in the opportunity.




Lastly, there were no additional comments or thoughts.

## 2. Conclusions and Recommendations

The survey carried out showed that the Polish public has an average knowledge of the main adaptive factors of the technology use in agriculture. However, when going into detail and asking for specific, more detailed information, they mostly lacked a wide range of knowledge.

The survey displayed that the areas in which Poles are most lacking in knowledge and which should be discussed more widely include:

- The concept of artificial intelligence (AI) and its applications in agriculture;
- Use of any AI-powered tools or technologies in the agricultural activities;
- AI use in the context of classifying and identifying weeds in agricultural fields;

- AI use in the context of development of predictive models for disease outbreaks in crops or livestock;
- AI use in the context of analysing historical data to optimize crop rotation practices;
- Governmental initiatives or programs aimed at promoting digitalisation and AI adoption in agriculture;
- Support available, such as funding and technical assistance, to help farmers and agricultural businesses adopt AI and digital technologies.

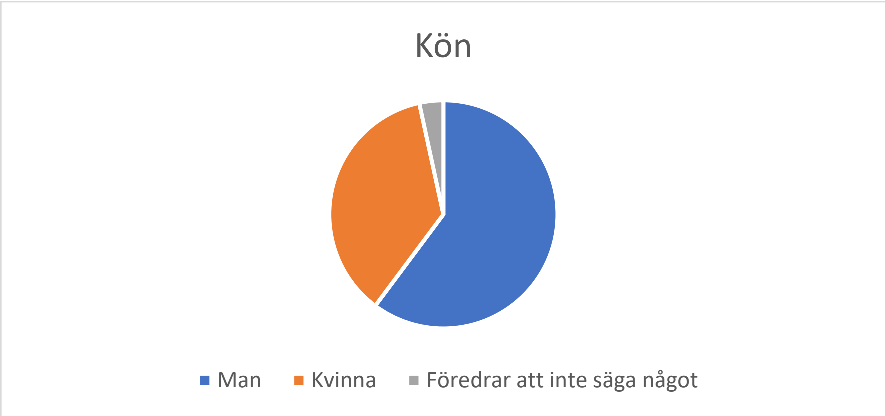
This situation illustrates the reality in Polish agriculture and underlines the real need to implement projects such as AI4Agri in order to sensitise farmers and other agricultural workers, both current and future ones, to important issues and increase their knowledge and competence.

# Needs assessment survey analysis in Sweden

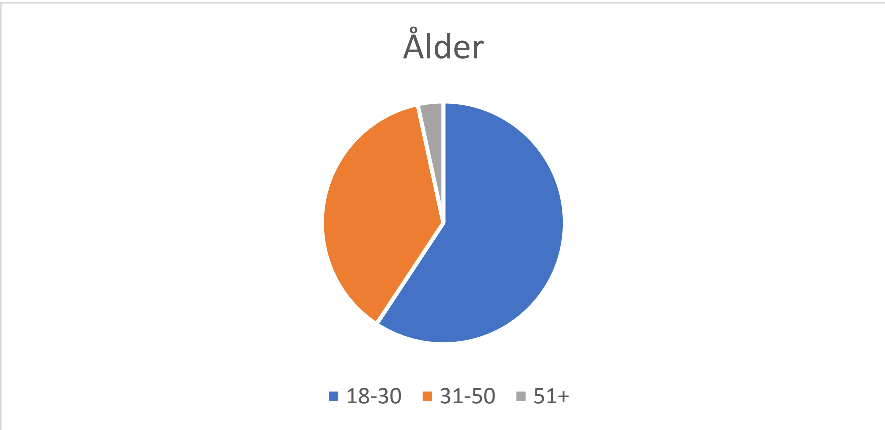
## 1. Results and discussion

The survey was conducted between April and May 2024 by distributing questionnaires to the local community, specifically targeting individuals involved in agriculture, including owners, employees, experts, and potential agricultural entrepreneurs

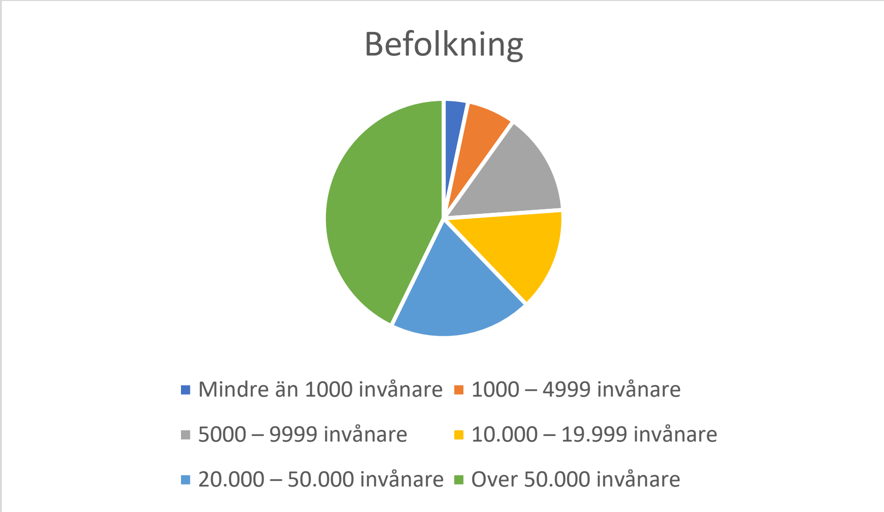
**Demographics**




The chart breaks down the survey participants by gender. The majority, 60,2% (71 participants), identified as men. Women comprised 36,4% (43 participants), and there were 4 respondents (3.4%) who did not disclose their gender.

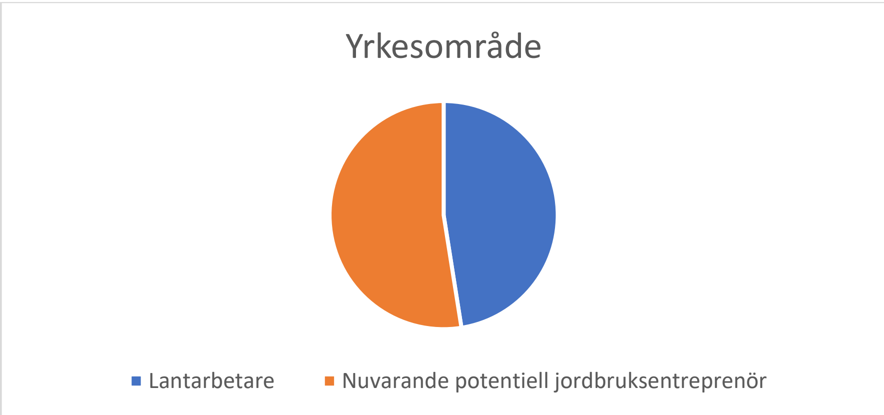



The age breakdown of the survey participants is shown in the pie chart. The largest group, at 59,3% (70 participants), falls between 18 and 30 years old. Those aged 31-50 make up 37,3% (44 participants), while 3,4% (4 participants) are over 50.

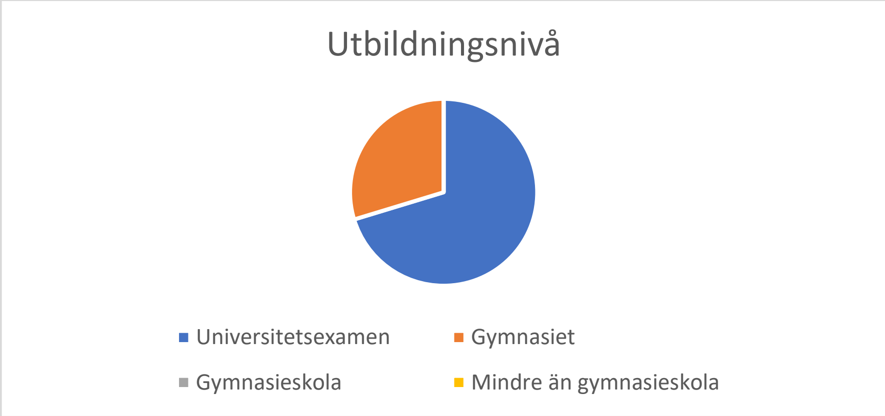



The analysis of respondent residence revealed a geographically diverse distribution across various cities sizes. The most prominent concentration (44.1%, 52 participants) resides in urban areas exceeding 50,000 inhabitants. Notably, a substantial segment inhabits smaller towns, with an even distribution between the 10,000-19,999 (14,4%) and 20,000-50,000 (16,9%) population ranges. A relatively balanced representation exists within even smaller communities: 14.4% (17 participants) reside in towns with populations between 5,000 and 9,999 and another 14.4% (17 participants) between 10,000 and 19,999, while approximately 6.8% (8 participants) inhabit locations with 1,000 and 4,999 inhabitants and 3,4% with less than 1000 inhabitants.

**Specific information**




The survey revealed that nearly half (47.5%) of the respondents are currently employed in agriculture and a slightly larger proportion (52.5%) identified as existing or potential agricultural entrepreneurs.



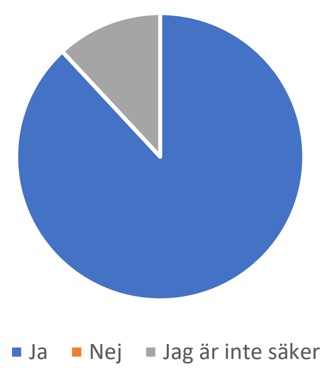

Focusing on the educational background, the chart reveals that 70.3% of respondents possess university degrees. The remaining respondents (29.7%) have completed higher education programs.


The survey revealed a diverse range of agricultural activities currently or possible undertaken by respondents. Nearly half (46.6%, 55 participants) are involved in crop production. Following closely are those engaged in agroforestry (27.1%, 32 participants) and mixed farming (16.1%, 19 participants). Indoor farming follows with 4.2% (5 participants) and agro-processing with 2,5% (3 participants). A small number of respondents indicated involvement in livestock farming (1.7%, 2 participants), with a single participant specifying hydroponics (0.8%) and agricultural research & development (0.8%).

Hur får du tillgång till information och resurser som rör jordbruk och entreprenörskap i din region?

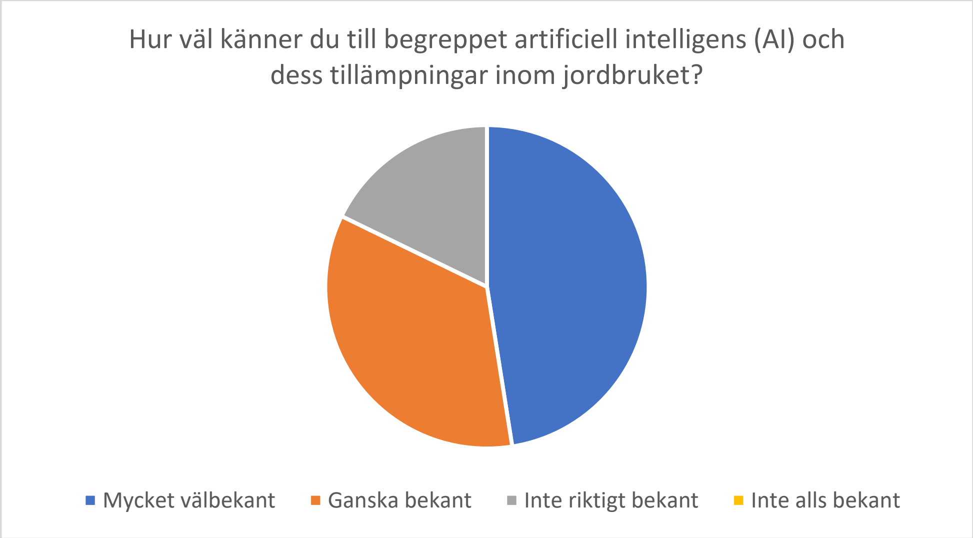

The data reveals three prominent sources for accessing information and resources related to agriculture and entrepreneurship in the participants' regions. Online resources, encompassing websites, forums, and social media platforms, lead the pack with a significant number of responses (49), representing over 41.5% of participants. Networking/peer conversations (26 responses) follow closely behind at 22%, and educational institutions (18 responses) account for 15,3% of participants. Interestingly, a 7,6% of the participants access information through agricultural service providers (9 participants). Books, publications, and industry reports were mentioned by 5,1% (6 participants), NGOs and industry associations were mentioned by 4,2% (5 participants), industry conferences and trade shows by 3.4% (4 participants), and government agencies and programs by 0.8% (1 participant).

Skulle du säga att du håller dig uppdaterad om marknadstrender, tekniska framsteg och bästa praxis inom jordbruket?



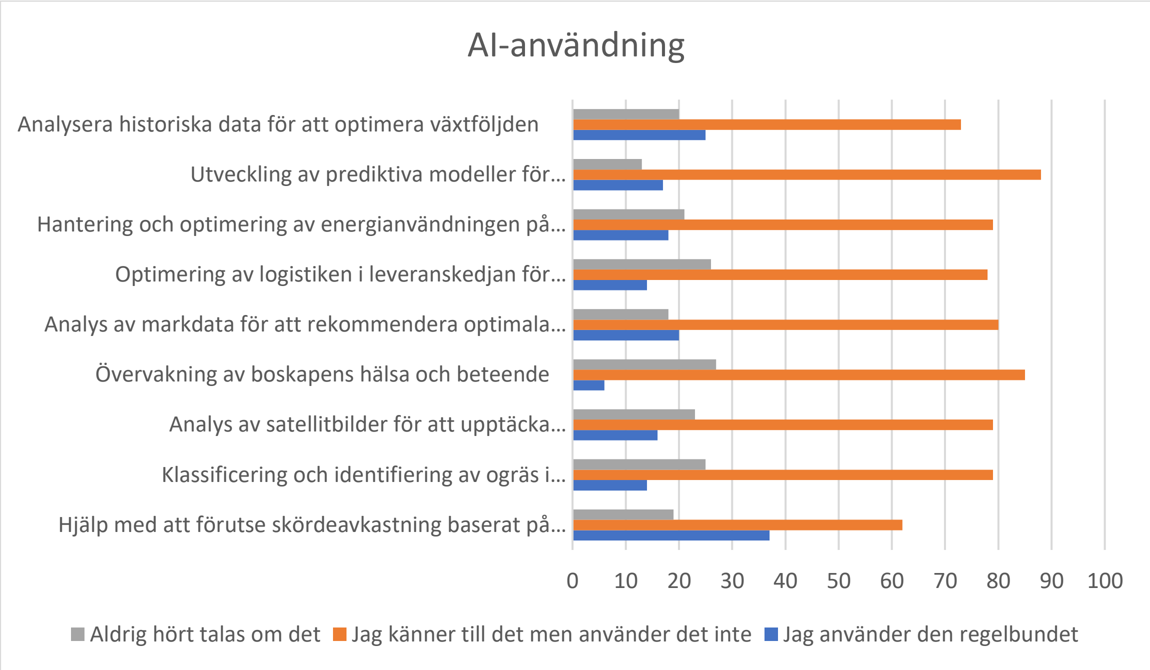
The survey assessed the respondents' level of awareness regarding market trends, technological advancements, and best practices within their field. An overwhelming majority (88.1%, 104 participants) indicated that they feel well-informed. The remaining participants (11.9%, 14 participants) expressed uncertainty about their level of awareness.

**Digitalisation and AI use**



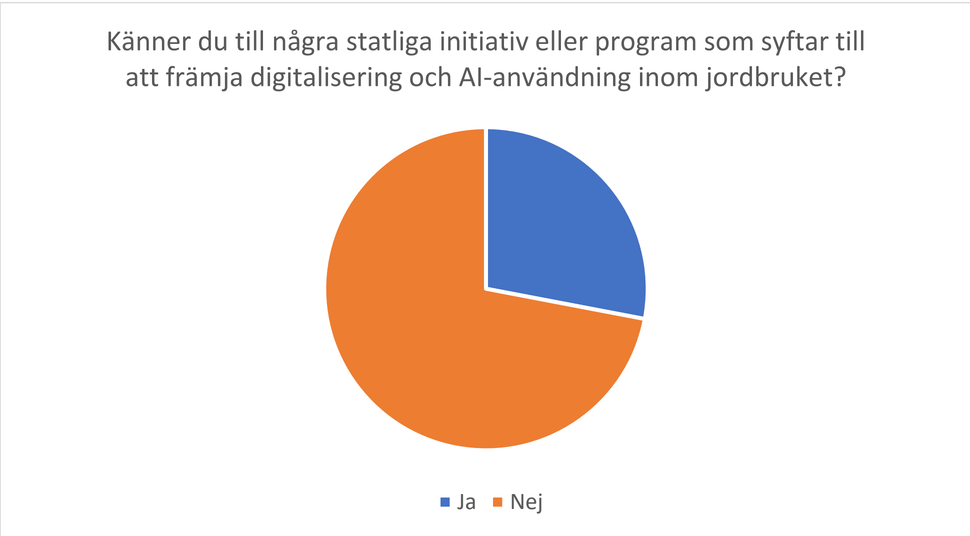

The graph explores the respondents' familiarity with artificial intelligence (AI) and its potential applications in agriculture. A significant portion (47.5%, 56 participants) indicated they are highly familiar with the concept of AI. An additional 34.7% (41 participants) reported being rather familiar. This suggests a strong foundation of AI awareness among a large majority of respondents (82.2%). However, a smaller segment (17.8%, 21 participants) acknowledged they are not really familiar, while none (0%) indicated no familiarity at all.

While a notable portion (33.9%, 40 participants) reported personal experience with AI tools, nearly two-thirds (66.1%, 78 participants) indicated they haven't yet utilized them in their practices.




In terms of AI use, the majority of the participants are aware of the AI applications and technologies but there is a significant gap between awareness and adoption. More specifically, “Assistance in predicting crop yields based on weather data and historical trends”, 37 respondents answered that they use it regularly, 62 responded that they know about it but do not use it and 19 responded that they do not know it at all. “Classifying and identifying weeds in agricultural fields” is used by 14 respondents, while 79 have heard about it but do not use it and 25 have never heard about it. “Analysis of satellite imagery to detect crop health issues” is regularly used by 16 respondents, 79 respondents have heard about it but do not use it and 23 have never heard about it. “Monitoring livestock health and behaviour” is used by 6 people, while 85 have heard about it but do not use it and 27 do not know about it at all. In terms of “Analysing soil data to recommend optimal crop planting strategies”, 20 respondents know it and use it regularly, 80 have heard about it but do not use it and 18 do not know about it at all. Regarding “Optimising supply chain logistics for agricultural products”, 14 people know about and use AI tools, 78 people know about it but have never used it and 26 do not know about it at all. 18 people use AI technologies for managing and optimizing energy usage on farms, 79 have heard about it but never used it and 21 have never heard about it. 17 people know about and use AI tools for the development of predictive models for disease outbreaks in crops or livestock, 88 have heard about it but do not use it and 13 do not know about it at all. Finally, only 25 participants know about and use AI tools to analyse historical data to optimize crop rotation practices while 73 have heard about it but do not use it and 20 do not know about it at all.


In terms of the main challenges encountered in adopting digital technologies and AI in their agricultural activities, 47,5% responded that main challenge is the cost for software, training and infrastructure, the 16,9 reported the integration with existing systems, 12,7% chose as the main challenge the data privacy and security concerns, the 11% chose the lack of awareness and education, only 4,2% responded that the main challenge is the limited technical support as well as the 4,2% chose that is too complex and hard to understand. Finally, 3,4% chose as the main challenge reliability and accuracy.

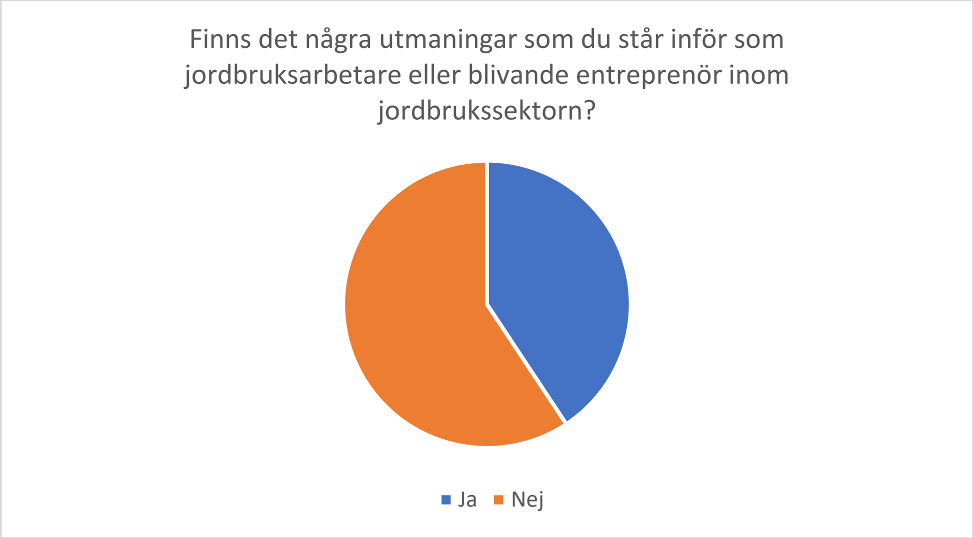



Regarding the knowledge of government initiatives or programmes aimed at promoting digitalisation and AI uses in agriculture, the vast majority (72%) answered that they are not aware of such initiatives while 24,6% responded that they do, not further elaborating. A total of 3,3% mentioned specific initiatives such as RISE and AI-kommission.


In the question "Do you believe that AI has the potential to improve efficiency and productivity in agricultural practices?", the vast majority has responded positively (94,1%) and only 5,9% that they are not sure.


Regarding the question "Do you think AI can help in addressing environmental challenges, such as climate change and resource depletion, in agriculture?" 98,3% (116 participants) of the respondents state that they believe so, 1,7% (2 participants) that they are not sure.

**Summary**




Regarding the challenges that the respondents face when it comes to their agricultural activities, 59,3% (70 participants) mention that they are not facing challenges and 37,3% (44 participants) that they do. 2,5% specifies climate change as the main challenge and 0,8 the lack of education.


In terms of the question "Do you think there is enough support available, such as funding and technical assistance, to help farmers and agricultural businesses adopt AI and digital technologies?", 77,1% of the participants (n=91) replied Yes, 11,9% (n=14) replied that they are not sure and 11% replied No (n=13).


Regarding the expression of interest in participating in training programs or workshops focused on AI and digital technologies in agriculture, 90,7% of the respondents answered that they would be interested and 9,3% that they would not be interested in such programs.

## 2. Conclusions and Recommendations

The main conclusion of the needs assessment survey in Sweden is that there is a high level of awareness about AI, with 82.2% of respondents familiar with its concepts but this is not associated with hand-on experience in AI applications. There is a notable gap between awareness and actual adoption, with only 33.9% having personal experience with AI tools, indicating a need for practical training and demonstrations to convert awareness into adoption.

There was a strong belief in AI's potential for efficiency, but less certainty about environmental impact, thus there should be further communication of the environmental benefits of AI, backed by research and case studies, in order to increase confidence in AI's role in sustainability.

Most respondents feel there is adequate support, and many are interested in further training, thus expanding existing support programs and developing new ones focusing on AI training will be beneficial.

# Needs assessment survey analysis in Cyprus

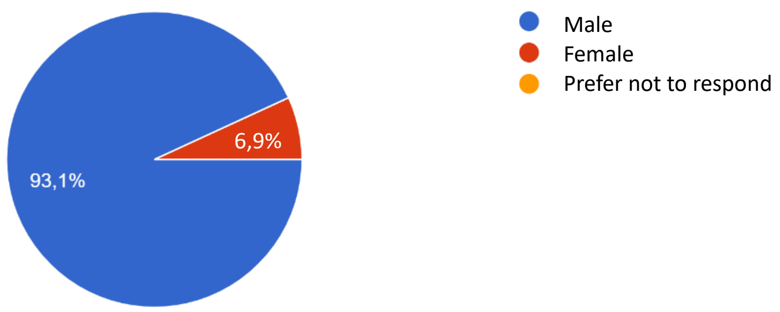
## 1. Results and discussion

The survey was conducted between April and May 2024 by distributing questionnaires to companies and individuals involved in agriculture, including owners, employees, experts, and potential agricultural entrepreneurs.

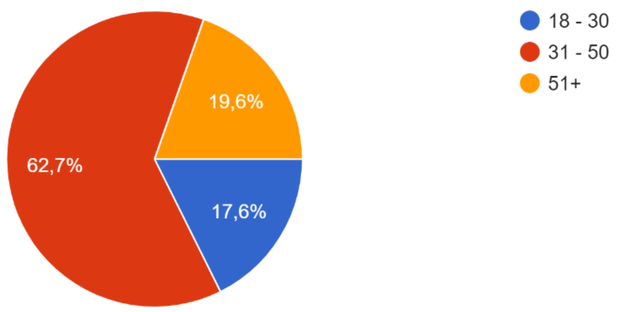
**Demographics:**

The first part of the survey was only aimed at collecting information on participants' profiles. Here are the statistical data collected.

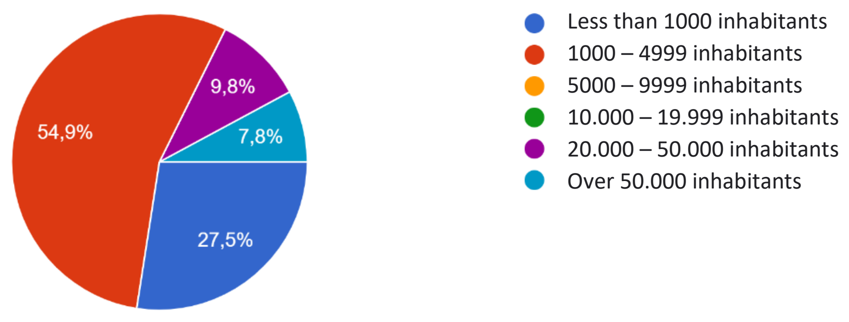
1- Gender




2- Age



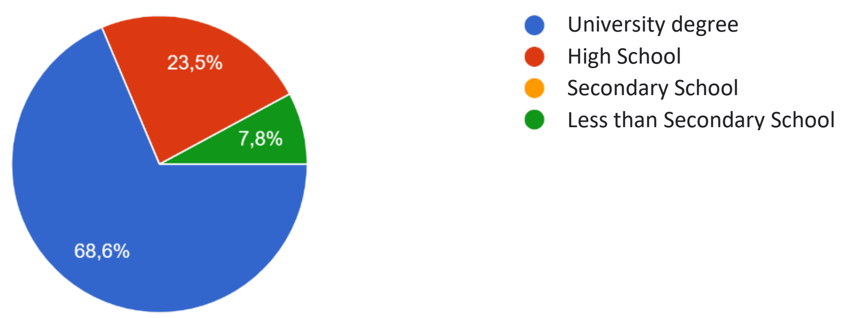
3- Population of your town



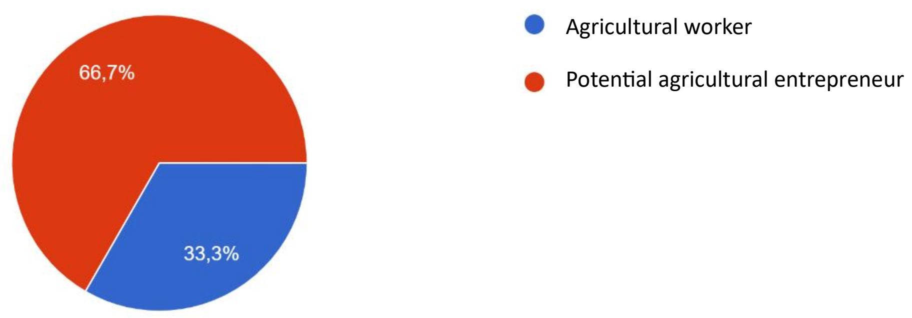

**Specific Information**

The second part of the survey was aimed at gaining insight on the agriculture representatives. Here is a graphical presentation of questions and answers received:

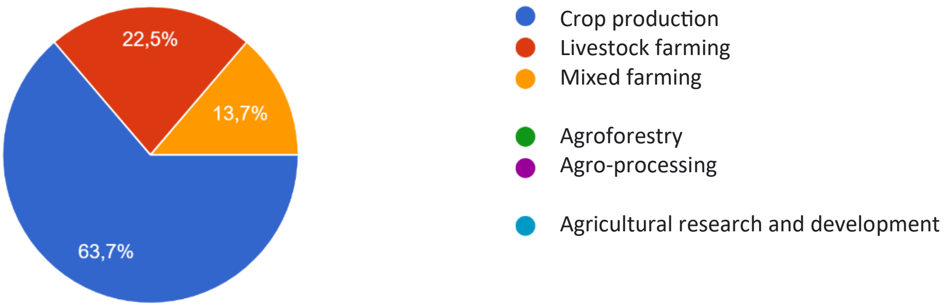
4- Education level



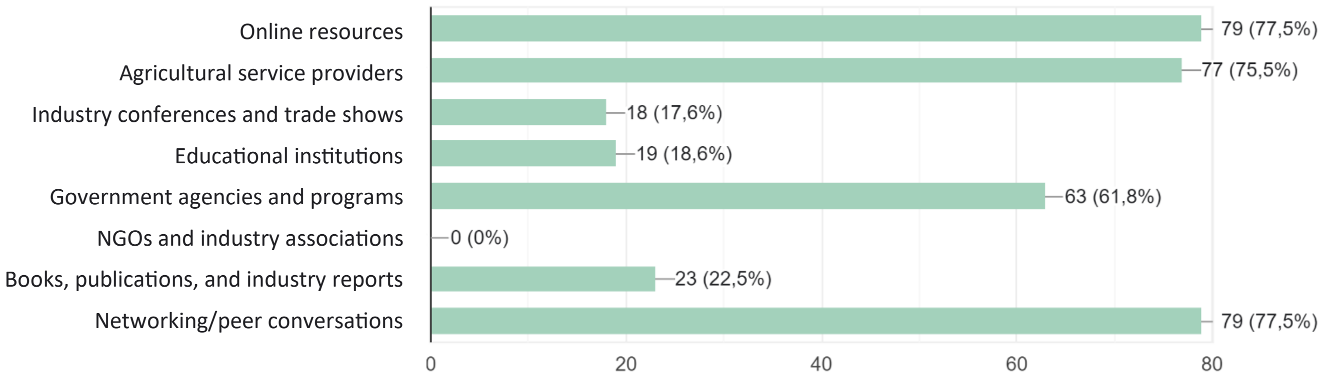

5- Field of work



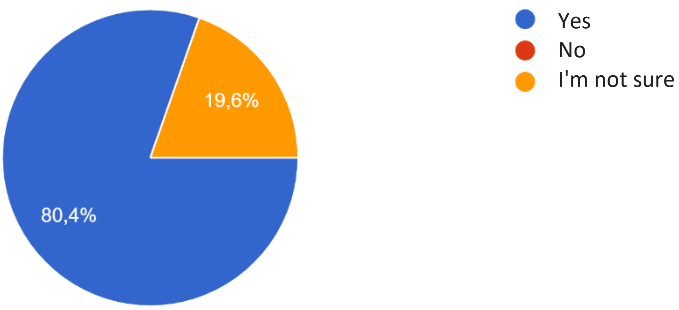
6- What type of agricultural activities are you currently involved in or interested in pursuing as a potential entrepreneur?




7- How do you access information and resources related to agriculture and entrepreneurship in your region?



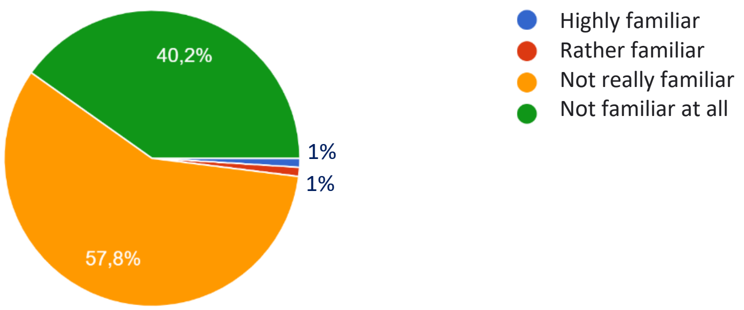

8- Would you say you stay updated on market trends, technological advancements, and best practices in agriculture?



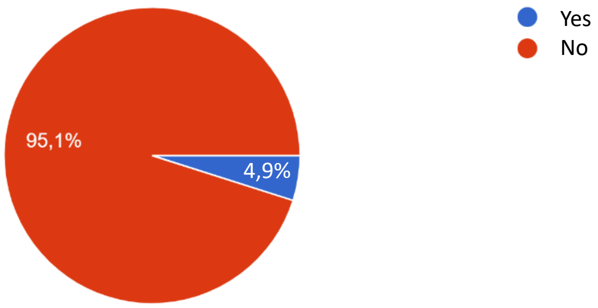
**Digitalisation and AI use**

The third part of the survey was aimed to access the knowledge of digitalisation and AI use in agriculture. Here is a graphical presentation of questions and answers received:

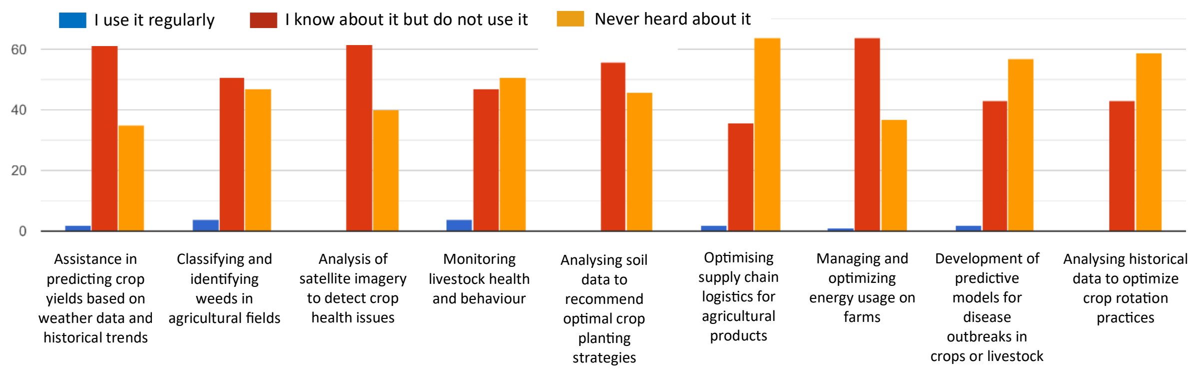
9- How familiar are you with the concept of artificial intelligence (AI) and its applications in agriculture.




10- Have you personally used any AI-powered tools or technologies in your agricultural activities?



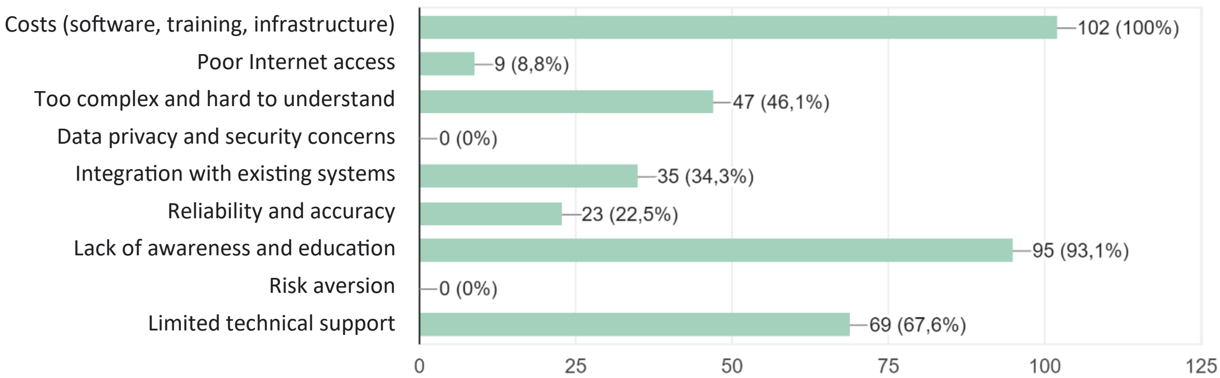

11- AI use



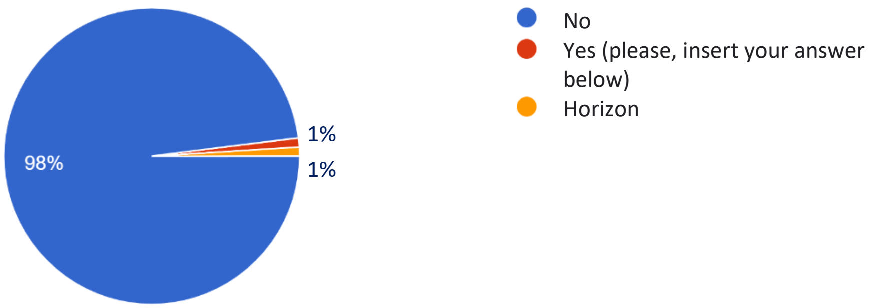

Regarding the use of AI, most of the participants responded with "I know about it but do not use it" or "Never heard about it". Although in the previous question only 5 (4,9%) participants answered that they have used AI tools in their activities, in this question we had more answers in the "I use it regularly".

*Assistance in predicting crop yields based on weather data and historical trends* is used by 2 participants, 65 of them know it but do not use, and 35 do not know it at all. *Classifying and identifying weeds in agricultural fields* is used by 5 of our participants, 50 of them know it but do not use, and 47 do not know it at all. *Analysis of satellite imagery to detect crop health issues* is not used at all, 62 of them know it but do not use, and 40 do not know it at all. *Monitoring livestock health and behaviour* is used by 4 participants, 47 of them know it but do not use, and 51 do not know it at all. *Analysing soil data to recommend optimal crop planting strategies* is not used by any participant, 56 of them know it but do not use, and 46 do not know it at all. *Optimising supply chain logistics for agricultural products* is used by 2 participants, 36 of them know it but do not use, and 64 do not know it at all. *Managing and optimizing energy usage on farms* is used only by 1 participant, 64 of them know it but do not use, and 37 do not know it at all. *Development of predictive models for disease outbreaks in crops or livestock* is used by 2 participants, 43 of them know it but do not use, and 57 do not know it at all. *Analysing historical data to optimize crop rotation practice* is not used by any participant, 43 of them know it but do not use, and 59 do not know it at all.

12- What are the main challenges you face in adopting digital technologies, including AI, in your agricultural operations?

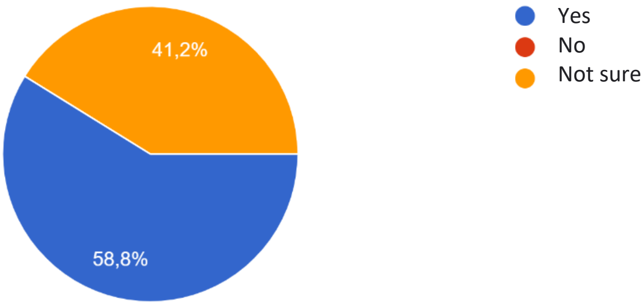



13- Are you aware of any government initiatives or programs aimed at promoting digitalisation and AI adoption in agriculture?

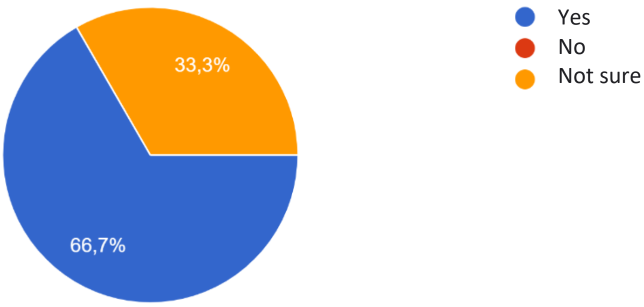



Only 2 people answer that they do know government initiatives or programs that promotes digitalisation and AI adoption, one did not further elaborate, and the other one mentioned the Horizon funding program.

14- Do you believe that AI has the potential to improve efficiency and productivity in agricultural practices?




15- Do you think AI can help in addressing environmental challenges, such as climate change and resource depletion, in agriculture?




**Summary**

Last part was a summary of questions. Here are the statistical data collected.

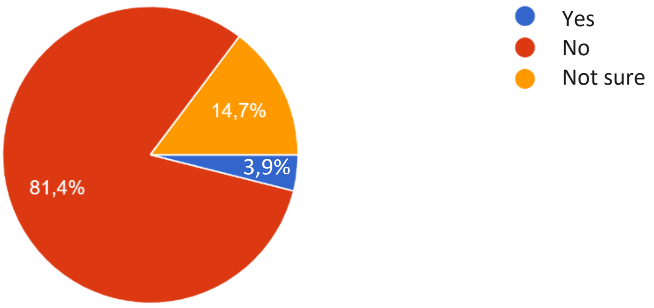
16- Are there any challenges you face as an agricultural worker or aspiring entrepreneur in the agricultural sector?


There wasn't a no for an answer, all the answers were yes with few comments which are:

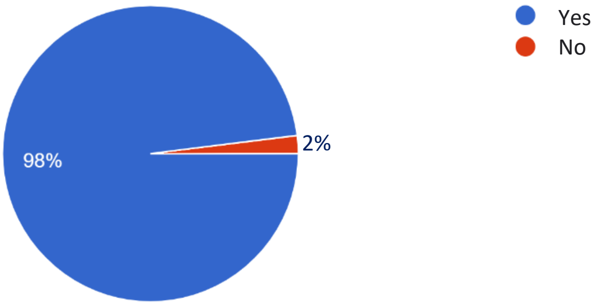
- All the problems a farmer can have, has them and will have them.
- Feed costs, drought, increase of fuel.
- The high cost of feed. Food needs to be imported. Also, the high price of fuel. Reduced rainfall.

- High cost of feed, high price of fuels, water shortage
- All the problems that a farmer has.
- Many.
- Drought, lack of resources due to high production costs

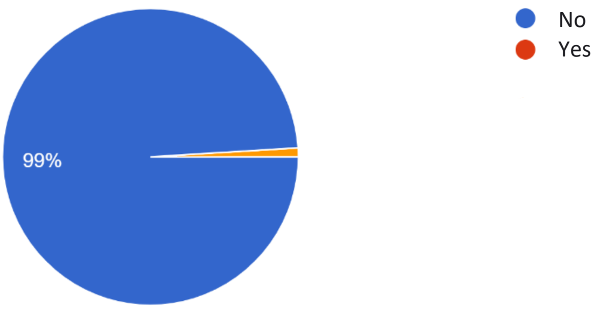
17- Do you think there is enough support available, such as funding and technical assistance, to help farmers and agricultural businesses adopt AI and digital technologies?




18- Would you be interested in participating in training programs or workshops focused on AI and digital technologies in agriculture?




19- Are there any additional comments or concerns you would like to share?




There was only one comment:

- In Cyprus we have not developed the tools yet, data-based, for decision making. Therefore, we should do this first and then use the artificial intelligence.

## 2. Conclusions

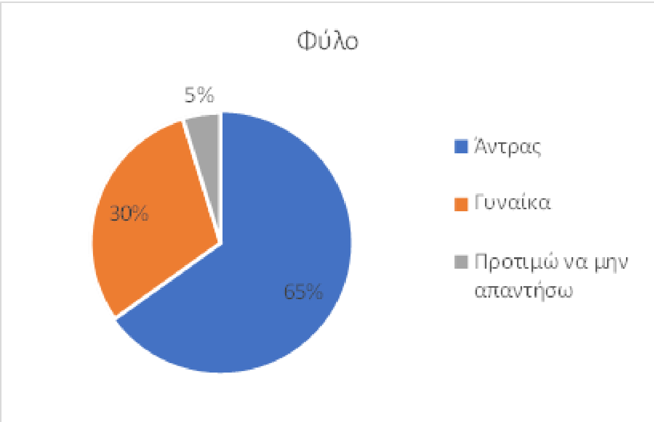
The survey reveals a very low level of knowledge and implementation of AI use in agriculture in Cyprus. Although almost all the participants replied that they are not really familiar or not at all familiar with the AI and have not use AI technologies, more than half seems to know different uses of AI in agriculture. It also reveals an interest from participants to increase knowledge in these field and are willing to participate in training programs. Agriculture workers and entrepreneurs face a number of barriers of integration of AI technologies, among which are the costs and a lack of awareness and education, and there is not enough support (funding and technical assistance) available.

# Needs assessment survey analysis in Greece

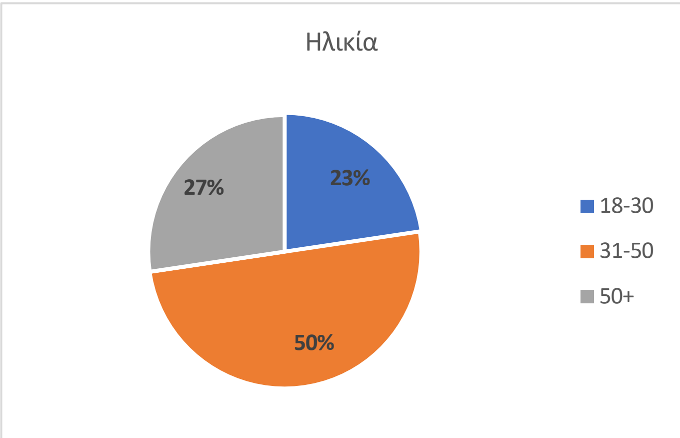
## 1. Results and discussion

This survey was conducted in April 2024 by contacting individuals relevant to the subject at hand and distributing questionnaires of which the results will be presented below. Several agricultural workers completed the questionnaire as well as potential agricultural entrepreneurs.

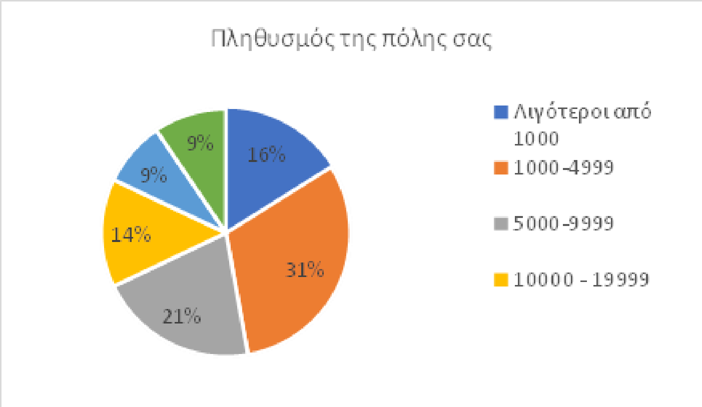
**Demographics**




The chart above shows the division of the respondents' gender. Specifically, 69 people identified as men (65%), 32 identified as women (30%) and 5 wished not to answer the question (5%).

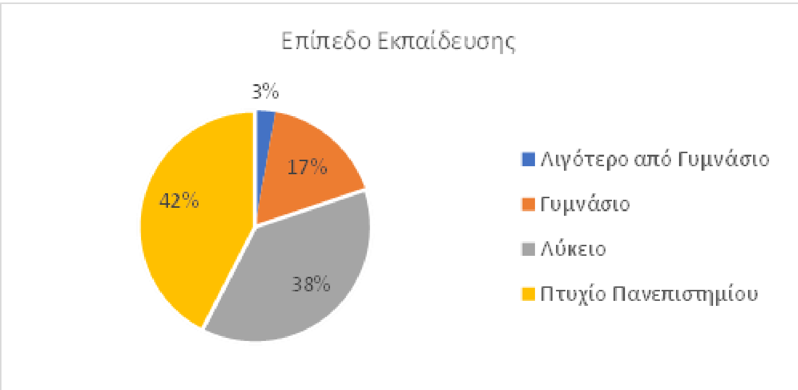



In the pie chart above, the age of the individuals that responded is recorded. 24 of the respondents were between the ages of 18-30 (23%), 53 were between 31-50 years old (50%) and 29 were over 50 years old (27%).



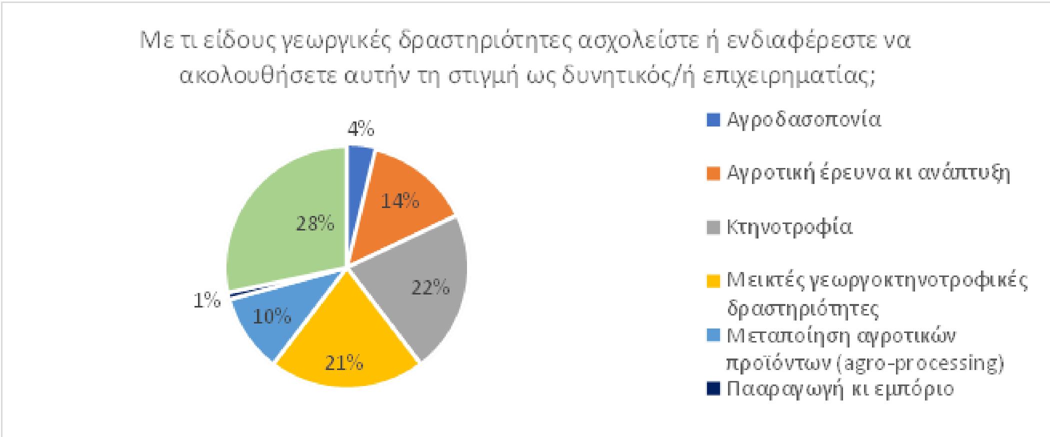

Regarding the population of the town of the respondents, the answers received varied. Most of the respondents live in a town where the population is between 1.000-4.999 residents, followed by the respondents that live in towns with a population between 5.000 and 9.999 residents. 16% of the respondents are resident in towns with fewer than 1000 inhabitants and 14% in towns with a population between 10.000 and 19.999 people. Finally, respondents from towns with populations of 20.000 and 50.000 and over 50.000 each made up 9% of the total of respondents.

**Specific information**

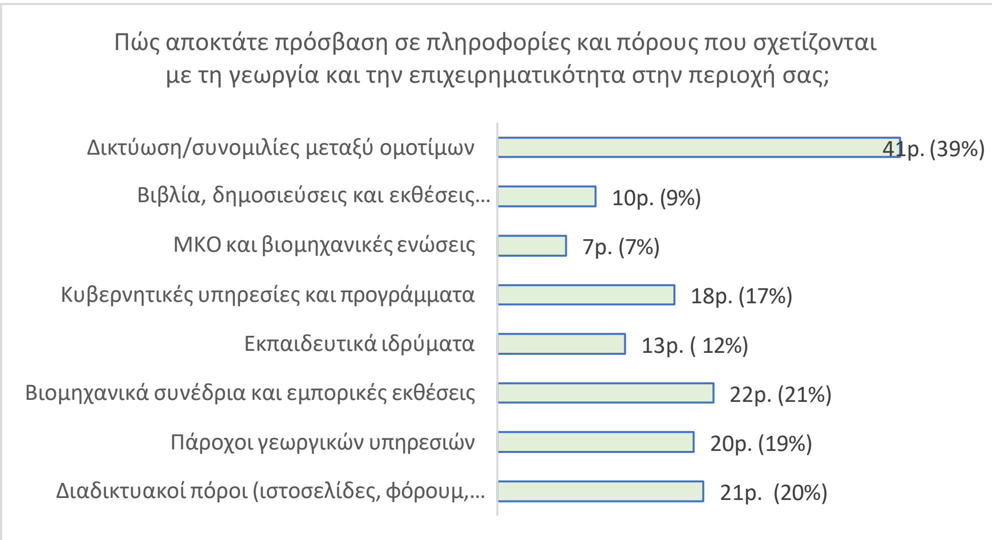



The above chart demonstrates the level of education of the respondents. 42% of the respondents have a university degree while 38% have finished higher education. 17% have finished secondary school and 3% less than secondary school.


In terms of field of work, 64% of the respondents are agricultural workers while 36% are potential entrepreneurs in agriculture.



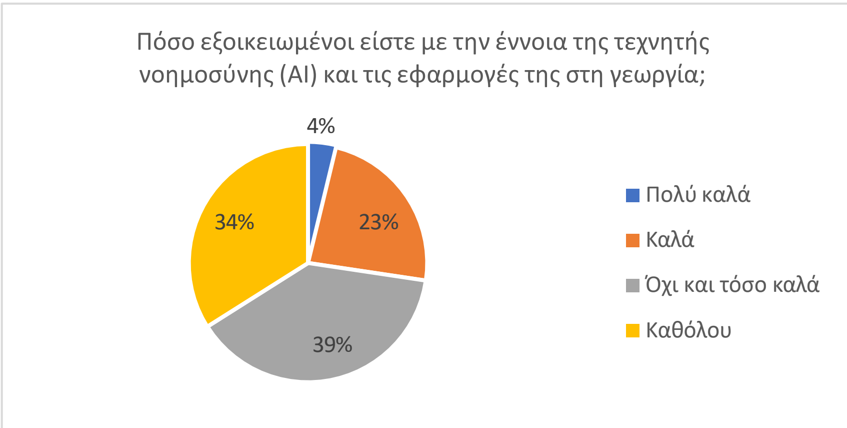

There are a variety of responses when it comes to the types of agricultural activities that the respondents are undertaking. 28% of the respondents are involved in crop production, while 22% are working in livestock farming and 21% in mixed farming. The 14% is working in agricultural research and development and 10% in agro-processing. Agroforestry represents 4% of the total of respondents and only 1% is dealing with production and trade.



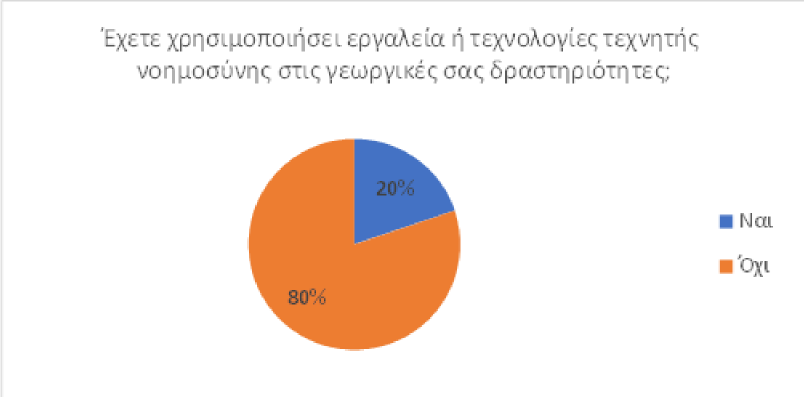
The above graph represents the responses recorded to the question on how the respondents access information and resources related to agriculture and entrepreneurship in their region. A number of respondents gave multiple answers which is represented here with a and to this end, 39% of the recorded responses (41 individuals) gain access through networking and peer conversations. 21% of the respondents (22 people) gain access through Industry conferences and trade shows while 20% (21 people) are informed through online resources and 19% (20 people) through agricultural service providers. A slightly smaller number (17% - 18 people) access information through government agencies and programs and finally, a smaller number of people are informed through other means, specifically: 12% (13 people) by educational institutions, 9% (10 people) by books, publications and industry reports and finally, 7% by NGOs and industry associations.


When it comes to how informed the respondents are in terms of market trends, technological advances and best practices in their field, almost half of them (49%) state that they are well informed, 22% state they are not well informed and the remaining 29% are not certain they are well informed.

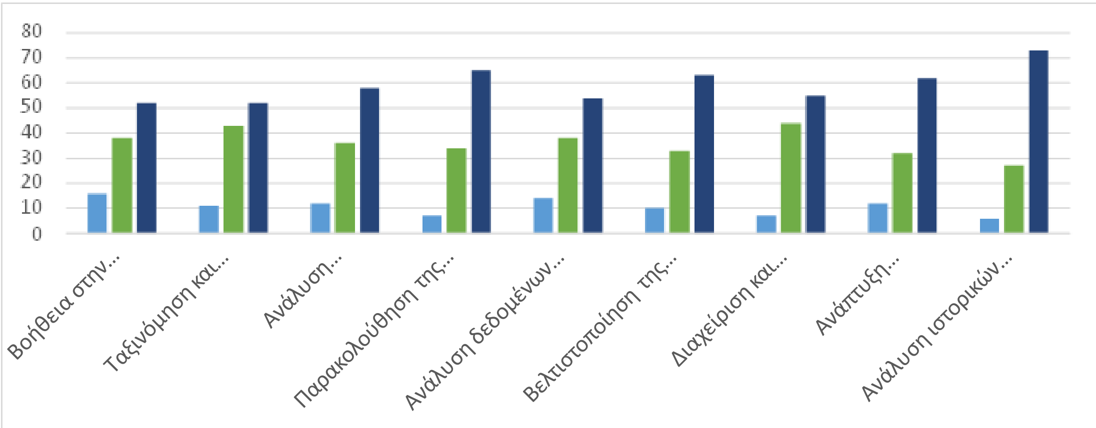
**Digitalisation and AI use**




The above graph demonstrates the respondents' familiarity with the concept of AI and its applications in agriculture. Specifically, 39% believe they are not really familiar with the concept, while 34% of the respondents state that they are not familiar at all. 23% state they are quite familiar with the subject and a very small 4% is very well acquainted with the concept of AI.

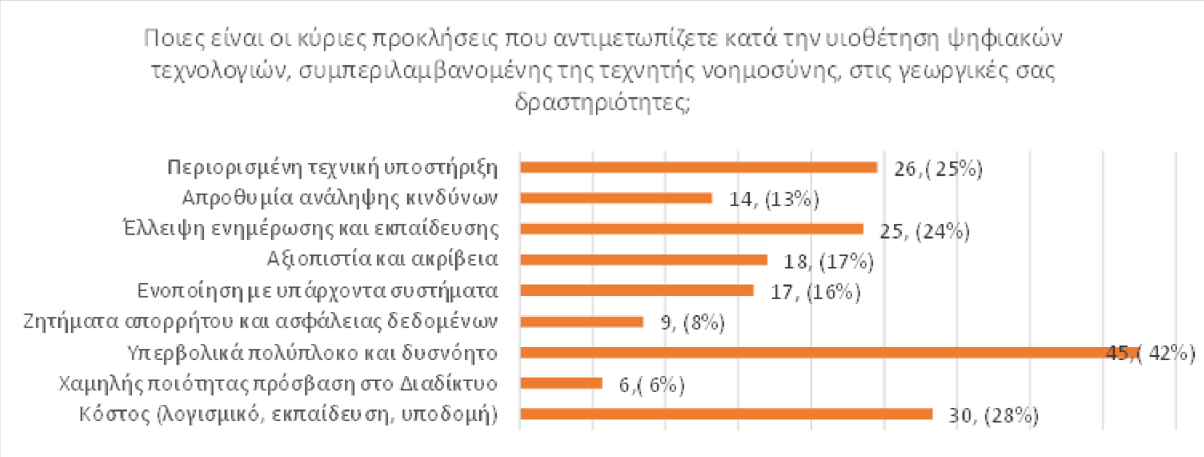



80% of the respondents have answered that they have never used any AI tools or technologies in their agricultural activities while only 20% responded that they have.

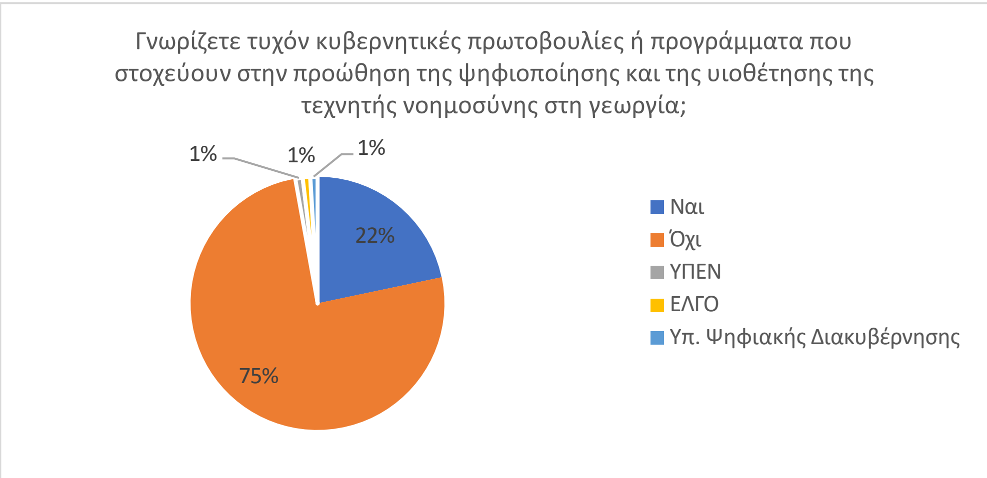



Regarding AI use and in line with the previous question, most of the respondents have stated that they do not know of the selected uses of AI in the agricultural sector.

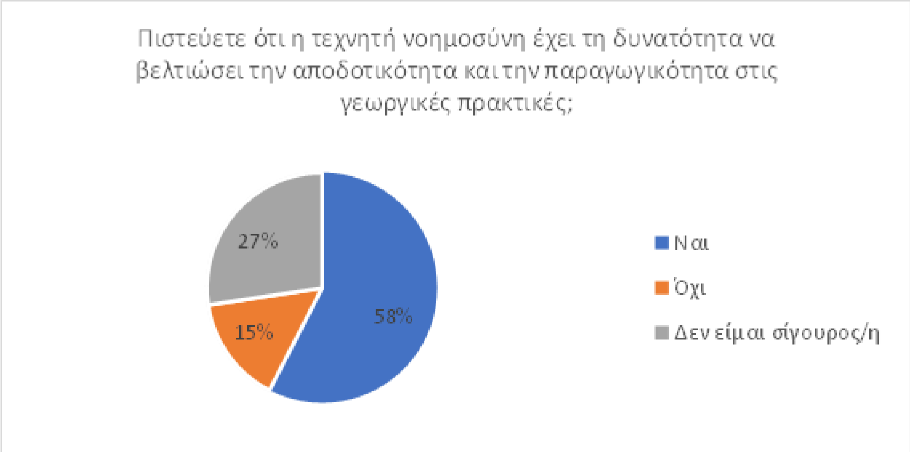
In more detail, for “Assistance in predicting crop yields based on weather data and historical trends”, 16 respondents answered that they use it regularly, 38 responded that they know about it but do not use it and 52 responded that they do not know it at all. “Classifying and identifying weeds in agricultural fields” is used by 11 respondents, while 43 have heard about it but do not use it and 52 have never heard about it. “Analysis of satellite imagery to detect crop health issues” is known and regularly used by 12 respondents, 36 respondents have heard about it but do not use it and 58 have never heard about it. “Monitoring livestock health and behaviour” is known and used by 7 people, while 34 have heard about it but do not use it and 58 do not know about it at all. When it comes to analysing soil data to recommend optimal crop planting strategies, 14 respondents know it and use it regularly, 38 have heard about it but do not use it and 54 do not know about it at all. 10 people know about and use AI tools for “Optimising supply chain logistics for agricultural products”, while 33 people know about it but have never used it and 63 do not know about it at all. 7 people use AI technologies for managing and optimizing energy usage on farms, 44 have heard about it but never used it and 62 have never heard about it. 12 people know about and use AI tools for the development of predictive models for disease outbreaks in crops or livestock, 32 have heard about it but do not use it and 62 do not know about it at all. Finally, only 6 participants know about and use AI tools to analyse historical data to optimize crop rotation practices while 27 have heard about it but do not use it and 73 do not know about it at all.



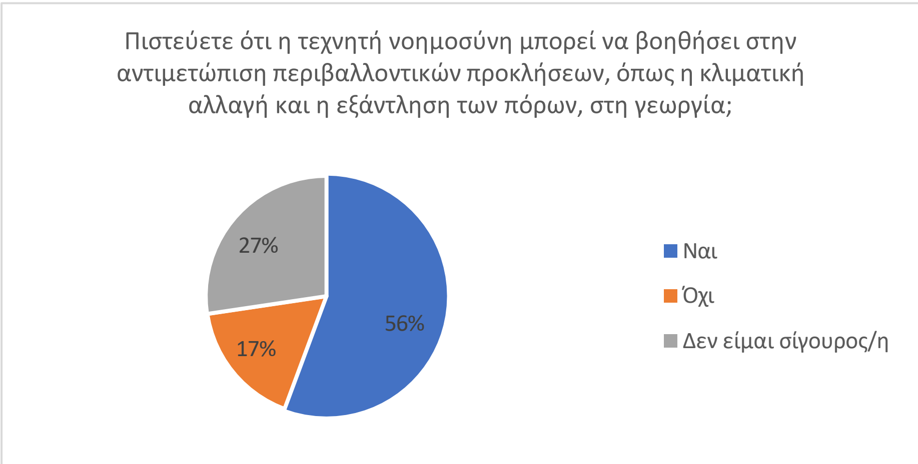

When it comes to the main challenges encountered in adopting digital technologies, including AI, in their agricultural activities, 42% responded that they are too complex and hard to understand. This is followed by a 28% that responded that a main challenge is the cost for software, training and infrastructure and a 25% which find that there is limited technical support. 24% also believe that there is a lack of awareness and education, 18% that there is lack of reliability and accessibility and 17% identify integration with existing systems as a challenge. 14% of respondents also state risk aversion as a challenge while 8% mention data privacy and security concerns and 6% mention poor internet access.




In terms of knowledge of government initiatives or programmes aimed at promoting digitalisation and AI uses in agriculture, the vast majority (75%) answered that they are not aware of such initiatives while 22% responded that they do, not further elaborating. A total of 3% mentioned specific initiatives through the Ministry of Environment and Energy, the Ministry of Digital Governance and Hellenic Agricultural Organization (ELGO).

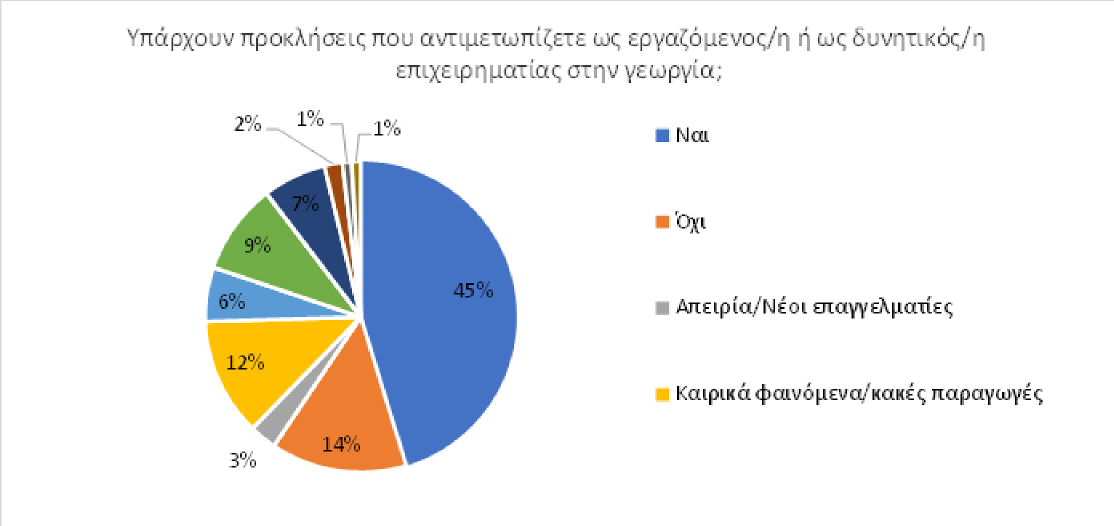



In the question "Do you believe that AI has the potential to improve efficiency and productivity in agricultural practices?", 58% answered positively, 27% that they are not sure and 15% stated that they do not believe so.

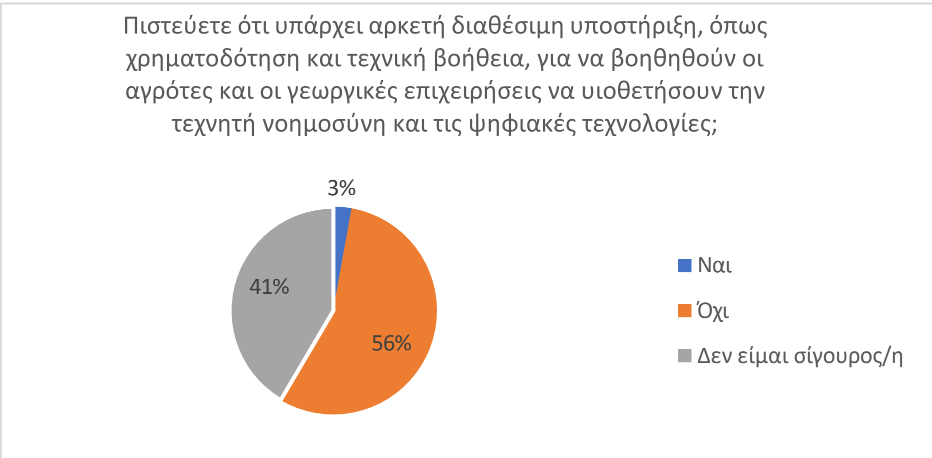



Regarding the question "Do you think AI can help in addressing environmental challenges, such as climate change and resource depletion, in agriculture?", 56% of the respondents state that they believe so, 27% that they are not sure and 17% that they do not believe so.

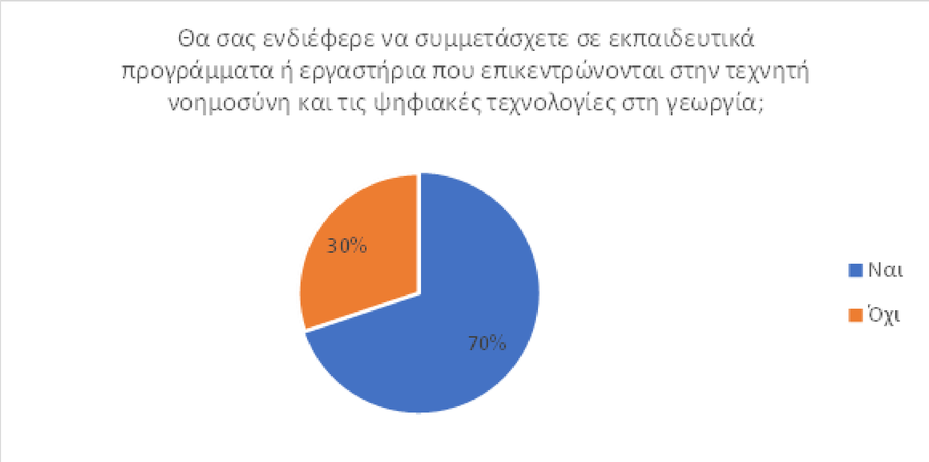
## Summary



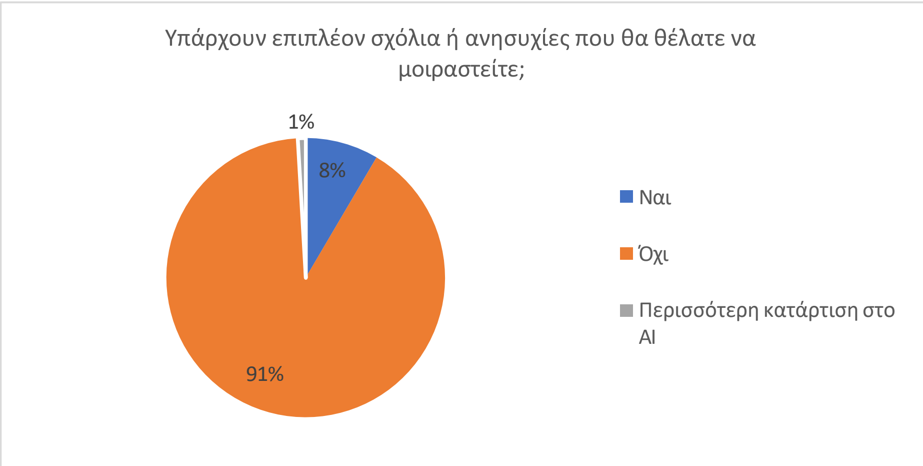

Regarding the challenges that the respondents face when it comes to their agricultural activities, 45% mention that they are facing challenges and 14% that they do not. 12% mention specifically bad weather conditions and subsequent bad crop production, while 9% mention lack of training and information on AI practices. 7% state the lack of financial resources and governmental support as a challenge and 6% plant diseases. The remaining 7% state the following as challenges: young professionals/lack of experience, lack of access to relevant equipment, lack of accessibility, fast development of tools with no sufficient scientific information on the results of their use.




In the question "Do you think there is enough support available, such as funding and technical assistance, to help farmers and agricultural businesses adopt AI and digital technologies?", 56% of the participants replied Yes, 41% replied that they are not sure and 3% replied No.




In terms of interest in participating in training programs or workshops focused on AI and digital technologies in agriculture, 70% of the respondents answered that they would be interested and 30% that they would not be interested in such programs.




Finally, in the question "Are there any additional comments or concerns you would like to share?", 91% responded with No, 8% with Yes but no further elaboration and 1 person responded that they wish for more training in AI uses.

## 2. Conclusions and Recommendations

The main conclusion drawn from the survey conducted in Greece is that when it comes to AI technologies being used in the agricultural field, the majority of the workforce, be it agricultural workers or potential entrepreneurs, either is vaguely familiar or not familiar at all with such concepts. There is a small number that is working with AI technologies but in general, there is a lack of knowledge on the subject.

The most prominent issues that stem from the survey conducted regarding the Greek agricultural workers and entrepreneurs and should be further discussed are the following:

- Little to no familiarity with the concept and uses of AI in the agricultural field
- Lack of sufficient training and relevant initiatives for AI uses in the agricultural field and the interest of agricultural workers/entrepreneurs to participate in such trainings and initiatives
- Lack of knowledge for uses of AI tools in the agricultural field for any of the following mentioned in the survey:

  - Assistance in predicting crop yields based on weather data and historical trends
  - Classifying and identifying weeds in agricultural fields
  - Analysis of satellite imagery to detect crop health issues
  - Monitoring livestock health and behaviour
  - Analysing soil data to recommend optimal crop planting strategies
  - Optimising supply chain logistics for agricultural products
  - Managing and optimizing energy usage on farms
  - Development of predictive models for disease outbreaks in crops or livestock
  - Analyse historical data to optimize crop rotation practices
- The lack of governmental initiatives that can promote digitalisation (including AI uses) in the agricultural sector
- The potential technical support such as funding and technical assistance that could help farmers and agricultural businesses adopt AI and digital technologies.

## Summary of the Needs Assessment Survey

**Demographics:**

From the total 431 participants of the survey 294 were men, 128 women and 9 participants did not disclose their gender. The lowest participation from women was in Cyprus with only 7 participants.

39.2% aged between 18-30, 48% between 31-50 and 12.8% 51+. In Poland and Sweden most of the responders were aged between 18-30 followed by 31-50 whereas in Greece and Cyprus most of the responders were aged between 31-50, followed by 51+ and 18-30.

Regarding the population of the town of the participants, the answers varied in all countries. In Sweden the most prominent concentration lives in urban areas exceeding 50,000 residents. In Poland, Greece and Cyprus most of the participants live in communities with population between 1.000-4.999 residents.

**Specific Information:**

59.7% of the participants have a university degree, 33% have finished high school, and 7,3% have finished secondary school or less.

In the field of work, 49% of the respondents are agricultural workers and 51% are potential entrepreneurs in agriculture.

Regarding the agriculture activities they are currently involved in or interested in pursuing as potential entrepreneurs, the survey revealed a diverse range of activities in all countries except Cyprus where the participants are involved only in 3 activities, crop production followed by livestock and mixed farming. In Poland the largest groups represent livestock farming and mixed farming, followed by crop production and agro-processing. In Sweden nearly half are involved in crop production, following closely those engaged in agroforestry and mixed farming. In Greece there was a variety of responses, crop production, livestock farming and mixed farming the first three followed by agricultural research and development and agro-processing.

In terms of how the participants access information and resources related to agriculture and entrepreneurship in their region the respondents gave multiple answers with a common source in all countries the online resources such as websites, forums, social media platforms. Beside the online resources, other sources are:
In Poland, educational institutions, and books, publications, and industry reports.
In Sweden, networking-peer conversations and educational institutions.
In Cyprus, networking-peer conversations, followed closely by the agricultural service providers and by government agencies and programs.
In Greece, networking-peer conversations which lead the pack, industry conferences and trade shows, and agricultural service providers follows.

When it comes to how informed the participants are in terms of market trends, technological advances and best practices in their field, in Sweden and Cyprus the majority indicated that they are well-informed (<80%) with the remaining expressing uncertainty about their level of awareness. In Poland over a half (55,2%) of the respondents stated that they are not sure if they are up to date, 36,2% stated that they are surely updated well and 8,6% responded they are not up to date. In Greece almost half

(49%) stated that they are well informed, 22% stated they are not well informed and the remaining 29% are not certain.

**Digitalisation and AI use**

Regarding the familiarity with the concept of AI and its applications in agriculture it seems that only in Sweden are well familiar with a significant portion (47.5%, 56 participants) indicated they are highly familiar with the concept of AI and an additional 34.7% (41 participants) reported being rather familiar. Unlike Sweden, in the rest of the countries over half of the participants are not really familiar (48%) or not at all (27.6%) familiar with the concept of artificial intelligence (AI) and its applications in agriculture with the respondents from Cyprus to be the less familiar from the rest of the countries. This highlights the need for training and resources to enhance their knowledge for AI uses in agriculture.

More than two-thirds (77.7%) of all participants have never used any AI tools or technologies in their agricultural activities. The lowest portion reported, was in Cyprus with only 4.9%, while in other countries range from 20 to 33.9%. This highlights the need for broader education on AI practices that can be adopted in agriculture activities.

Regarding AI use and in line with the previous question, most of the participants have stated "I know about it but do not use it" of the selected uses of AI in the agricultural sector.

The majority of the participants in Sweden are aware of the AI applications and technologies but there is a significant gap between awareness and adoption in all the uses stated in the survey whereas in Greece most of the respondents have stated that they do not know of the selected uses of AI. In Poland and Cyprus some uses are known but never used or never heard about them with Cyprus having the lowest use in all the selected AI applications. In Poland, Sweden and Greece, the most common use is the *Assistance in predicting crop yields based on weather data and historical trends* and in Cyprus the most common use is *Classifying and identifying weeds in agricultural fields.*

In terms of the main challenges encountered in adopting digital technologies and AI in their agricultural activities, almost 60% of all the participants responded as the main challenge the cost for software, training and infrastructure. Also, common challenge in all countries is the lack of awareness and education. In Poland beside the cost, participants also voted for poor Internet access (47.6%), (47%) and "Too complex and hard to understand" (41%). In Sweden, following the cost, 16,9% reported the integration with existing systems and 12,7% the data privacy and security concerns. In Cyprus after the cost and the lack of awareness and education, 67.6% chose the limited technical support. In Greece, first challenge was 'too complex and hard to understand' with 42%, followed by a 28% for the cost and 25% the limited technical support.

In terms of knowledge of government initiatives or programmes aimed at promoting digitalisation and AI uses in agriculture, the vast majority (83.4%) of all participants answered that they are not aware of such initiatives.
In Poland, 5.7% pointed at specific programmes such as agriculture 4.0, precision agriculture, and programmes managed by the Agricultural Restructuring and Modernisation Agency.
In Sweden, 3,3% mentioned specific initiatives such as RISE and AI-kommission.

In Greece, 3% mentioned initiatives through the Ministry of Environment and Energy, the Ministry of Digital Governance and Hellenic Agricultural Organisation (ELGO) and in Cyprus only 1 person mention the Horizon funding program.

In the question "Do you believe that AI has the potential to improve efficiency and productivity in agricultural practices?", the vast majority in Sweden has responded positively (94,1%) and only 5,9% that they are not sure. In the rest three countries 58,3% has responded positively, 34,5% are not sure and 7,2% didn't agree.

Similar to the above, in the question "Do you think AI can help in addressing environmental challenges, such as climate change and resource depletion, in agriculture?" almost all the participants (98,3%) in Sweden have responded positively and only 2 participants are not sure. In the rest countries, 57,4% has responded that they believe so, 32,5% that they are not sure and 9,2% that they do not believe so.

The answers to the above two questions indicate a need for raising awareness guidance regarding the environmental benefits of AI use in agriculture and the efficient improvement and productivity in agricultural practices.

**Summary**

Regarding the challenges participants face as agricultural workers or aspiring entrepreneurs in the agricultural sector there is a big contrast between the four countries.
In Poland and Sweden 80% and 59,3% respectively do not face any challenges while in Greece 45% and in Cyprus all the participants, 100% stated that they do face challenges.
In Poland the challenges mentioned are profitability of production, administrative difficulties, reliability or integration of equipment, lack of explanation in the delivery of new EU aid schemes, droughts, forest animals, energy prices, competition, changing demands, difficulty in selling crops, concerns about privacy, prices of products, fear for one's privacy, gaining access to the web, uncertainty of the industry, too much bureaucracy for officials, prices, red tape for authorities, bureaucratisation.
In Sweden the only challenges mentioned are climate change and lack of education.
In Cyprus the main challenges mentioned are reduced rainfall, drought, high cost of feed, high price of fuels, lack of resources due to high production costs.
In Greece the challenges mentioned are bad weather conditions and subsequent bad crop production, lack of training and information on AI practices, lack of financial resource and governmental support, plant diseases, young professionals/lack of experience, lack of access to relevant equipment, lack of accessibility, fast development of tools with no sufficient scientific information on the results of their use.

In the question "Do you think there is enough support available, such as funding and technical assistance, to help farmers and agricultural businesses adopt AI and digital technologies?" it seems that only in Sweden there is support where 77,1% of the participants replied Yes. In the other countries their answer was either No or Not Sure.

Addressing all the above challenges would require targeted education and support programs to help agriculture entrepreneurs and workers overcome barriers to implementing AI uses.

Regarding the expression of interest in participating in training programs or workshops focused on AI and digital technologies in agriculture, 88,5% of all the respondents answered that they would be interested while 11,5% did not state their interest in such programs with most of them to be in Greece.

In the additional comments or concerns that the participants would like to share, there were only 2 comments. In Cyprus 1 person mentioned that in Cyprus they haven't developed the tools yet, data-based, for decision making, so they should do that first and then use the artificial intelligence and 1 person in Greece responded that they wish for more training in AI uses.

## Reflection Roundtables between agriculture workers and AI experts

One roundtable discussion was held in each country to discuss issues related with the AI and agriculture. Agriculture workers, entrepreneurs, educators, students and AI experts exchanged ideas on the applications of AI in agriculture and reflect on the need assessment survey results in order to address and finalize the training needs assessment on the AI applications in agriculture.

In Poland, the roundtable was held face to face in the International Academy of Applied Sciences in Lomza between 10 participants, among them were educators, students in Smart Farming, students in Agrotronics and Precision Agriculture, potential entrepreneurs, AI experts.

In Sweden the roundtable was held online with 10 participants: AI experts, engineering educators, agriculture experts and potential entrepreneurs.

In Cyprus the roundtable was also held online between 10 participants, 6 agriculture entrepreneurs, 2 agriculture workers, 1 agronomist and 1 AI expert.

In Greece the 2 participating organizations, YET and ThinkOnception, conducted a common online roundtable with the participation of 9 people, agronomists, researchers, Coop Managers, farmers, ICT experts and Venture capitalists.

The following section provides the conclusions on the main aspects of the roundtables in each country.

# Reflection Roundtable in Poland

## 1. Conclusion on the main aspects of the Roundtable

### AI use in agriculture, opportunities and risks

During the discussions, the participants came to the reflection that Polish society is not yet fully familiar with the use of AI in agriculture, but they are trying to keep up to date with current trends and technical innovations. The most popular of the existing AI-powered applications in agriculture are those monitoring crops (weather prediction, monitoring of possible plant diseases, information on the best time to sow and harvest), but also intelligent irrigation systems.

The most prominent advantages of using AI in agriculture were identified by participants as:

- early detection of crop health issues such as nutrient deficiencies, pest infestations, and diseases;
- providing precise information on plant growth and health and enabling targeted application of fertilizers;
- helping farmers plan planting, irrigation, and harvesting activities;
- machine learning algorithms can distinguish between different types of diseases and recommend appropriate treatments;
- analysis of soil conditions, weather forecasts, and historical data to determine the best times for sowing and harvesting;
- monitoring soil moisture and weather conditions to optimize water usage.

Participants concluded that the ongoing low use of AI in agriculture may be due, among other things, to:

- concerns on data privacy;
- the initial cost of acquiring and implementing AI technologies;
- lack of technical expertise required to operate and maintain AI systems;
- over-reliance and loss of traditional knowledge;
- accuracy of predictions and algorithm bias in general.

Participants also accurately recognised that differences in attitudes towards AI use in agriculture may originate from differences in farm size. They mentioned that in small-scale farming it may be easier to monitor the AI's work, however, the initial costs may be quite high. In large-scale farming, on the other hand, AI use and especially automatization may help to lower operational costs, but it is also complex and requires vast knowledge, infrastructure and advanced management system.

When asked about age and educational level playing role in AI use in agriculture, the participants stated that the older generation may be resistant to the use of AI due to complex computer systems and the need to keep up to date with technical innovations and technological advances. In their opinion, the younger generation is definitely more open to the use of AI, nevertheless there is a risk that they will rely on it too much and, in case of possible problems with the system, they will not be able to get out of trouble.

Regarding income, the participants said that income level plays a crucial role in determining the extent to which farmers can adopt and benefit from AI-based applications in agriculture. High-income farmers may have greater access to technology, infrastructure, training, and market opportunities. In contrast, rural areas with lower income levels may lack the necessary infrastructure, hindering the adoption of AI technologies. Farmers with limited resources may struggle to access training and support services, making it challenging for them to maximize the potential benefits of AI in agriculture.

### Current training and policy needs

Participants identified the currently existing training on AI use in agriculture as courses related to AI and data analytics, precision farming tools, agroecology, and integrated pest management. In their opinion, our society still lacks educational support on pandemic response measures and farm resilience planning, programs focused on gender-inclusive policies, women's access to land and resources, and women's leadership in agriculture, as well as retaining youth in agriculture.

### Comments on the Survey analysis results

The survey findings highlighted important gaps in knowledge and awareness among the Polish society regarding the use of AI in agriculture. The key points that the participants suggested to consider are:

- educational programs and initiatives aimed at increasing awareness and understanding of AI technologies in agriculture;
- governmental initiatives and programs aimed at promoting digitalisation and AI adoption in agriculture;
- public awareness campaigns regarding the potential benefits of AI in agriculture;
- collaboration and knowledge sharing by creating platforms for sharing information, experiences, and resources related to AI adoption and digitalisation efforts; sensitizing farmers and agricultural workers to the importance of AI and digital technologies by continuous engagement, communication, and support.

### Further demands expressed

Further suggestions for improvement given by the participants included development of tailored training programs, demonstrating good practice examples, providing grants or subsidies on AI infrastructure, development of clear regulatory frameworks and standards for AI applications in agriculture, and establishment of networks and knowledge-sharing platforms for experience and best practice exchange.

## 2. Summary

AI technologies are already being used in various agricultural applications, such as crop monitoring, weather prediction, disease detection, smart irrigation systems, and optimizing sowing and harvest times. It enhances precision in monitoring crop health and growth, improves accuracy in weather forecasts to aid agricultural planning, and allows for early identification and treatment of plant diseases. It also optimizes sowing and harvesting schedules based on data analysis and ensures efficient water use through automated irrigation systems.

The participants indicated several risks associated with AI in agriculture, including data privacy and security concerns, high initial costs and technological barriers, potential over-reliance on AI systems, risks of biased algorithms and inaccurate predictions, potential job displacement and increased inequality, resource-intensive technologies leading to environmental concerns, and the need for proper regulations and ethical guidelines.

Addressing the existing needs and challenges through comprehensive strategies can promote AI adoption in Polish agriculture, enhancing productivity, sustainability, and resilience in the sector. This requires collaboration among all stakeholders to create an enabling environment for digital innovation in agriculture.

# Reflection Roundtable in Sweden

## 1. Conclusion on the main aspects of the Roundtable

### AI use in agriculture, opportunities and risks

Participants reported different levels of engagement with AI applications depending on their field of expertise, i.e. AI experts and educators contributed to the discussion with more detailed information about AI use and practicalities as well as agricultural experts and (existing/potential) entrepreneurs provided a more general perspective about their experiences. Many participants expressed their surprise with the high rates of awareness reported by the survey participants and discussed that this should be associated with the background and the age of the needs assessment survey respondents. Additionally, they reported as reasonable the gap between AI awareness and practical use due to the fact that AI is a relatively new concept and has not been adopted by the general public and agricultural workers/entrepreneurs yet due to the high initial costs and the lack of training.
Participants referred and analysed the *advantages* of AI use in agriculture such as benefits in the following aspects:

1. development of strategies for crop production (all phases);
2. prediction of plant health issues and diseases;
3. provision of farm-specific weather risk assessments mitigating weather related risks;
4. provision of sensors for soil moisture and temperature detection;
5. provision of drones together with automation technology to enable efficient and sustainable material handling in forestry and agriculture as well as drone-based crop management.
6. provision of scalability that is making the final output cheaper per farmer than before when supercomputing was utilised
7. contribution on food security and advance of developing markets
8. the final output that is used by the farmers can be quite simple to be easily used
9. the content creation is easier and more inclusive, since it can be translated in any language
10. accuracy improvements
11. decision making improvements
12. advance productivity and profitability

However, participants also reported *concerns* about AI use in terms of the following aspects:

1. initial costs as well as costs of maintenance and implementation
2. integration with existing systems
3. lack of awareness and expertise of the current workforce as well as
4. data privacy
5. development of “elites” of AI adoption that are integrating AI tools easily being able to afford the initial costs
6. possible bias of the algorithm that could provide false predictions and information
7. farmers can over-rely on AI for decision making instead of using it as a support tool

In terms of *AI applications in both small- and large-scale business as well as income*, participants agreed that the cost of acquiring, establishing and maintaining AI systems is possible to create and increase existing inequalities, since these systems are available only for large-scale farmers and entrepreneurs due to their high initial costs that prevent SMEs and small-sized farms to acquire and integrate them. However, a participant explained that developing an AI model takes an initial investment, but once it's built, it can be used to analyse data from many different farms, reducing the cost per farmer. For instance, when it comes to decision making AI applications, an AI model can be trained on large datasets and farmers can upload their data to the service receiving customized recommendations for their specific fields spreading the development cost of the AI model across many users.

In terms of *age and educational level*, participants reported that there is a need for raising awareness about technological improvements and integration on day-to-day operations in order to proceed on a national inclusive adoption of AI in agriculture industry. Many participants agreed on the fact that the AI applications that are finally used by the farmers are usually quite simplified to be deployed without any kind of advanced technical education. AI solution companies are usually providing a quick training to the users of applications explaining the application practicalities and its advisory content. Therefore, AI applications can be easily utilised by any farmer and the advanced AI expertise is required only by the Machine learning developers. The real current need is the development of a common understanding about AI advancements and use in agriculture.

### Current training and policy needs

In terms of training needs, the majority of the participants agreed that it is not mandatory for farmers and entrepreneurs to have advanced AI education, since this is the work of Machine learning developers. Farmers and entrepreneurs are the end-users of AI tools that are simplified and easy to use. However, there is a need for raising awareness on the digitalisation of Agriculture, the contribution of AI in sustainable development and green decision making focusing on elder workforce.

Participants referred the agricultural workers should be trained on (1) basic IT skills such as how to use the AI tools considering the differentiation between the applications; (2) soft skills such as communication and problem solving; as well as (3) green skills and terminology to develop a common understanding.

Participants referred that entrepreneurs should be trained on (1) basic IT skills in order to have a general overview; (2) soft skills such as communication and problem solving in order to collaborate with farmers and other stakeholders/occupational profiles as well as (3) green skills and terminology to develop a common understanding -as the agricultural workers.

A participant referred there would be a need for basic entrepreneurial skills for potential entrepreneurs.

In terms of policy needs, participants reported that there is much work to be done on regulations about data protection, privacy, and IP regulations. Simultaneously, there should be a national educational approach that will tackle geographical, generational and gender barriers to promote ethical AI use in agriculture protecting those with less opportunities. Finally, the need for financial assistance and a common financial approach for small-size enterprises and farms towards the minimization of potential inequalities due to the high initial costs was also reported.

### Comments on the Survey analysis results

During the Roundtable, many participants expressed that they didn't expect such significant results on AI awareness and described as reasonable the gap between awareness and AI practical use. They also commented that sample characteristics may shape this result that could be changed with a bigger sample size. Finally, they reported that more work should be done on awareness raising regarding the environmental benefits of AI use in agriculture.

### Further demands expressed

There were no further demands expressed.

## 2. Summary

There is a significant gap between the AI awareness and practical AI use that it is reasonable due to the fact that AI use in agriculture is an emerging concept. However, considering the correlation between AI awareness and age, there is a possibility of different results, if there were more participants above the age of 50.

Participants indicated both benefits and risks as well as focused on the governmental initiatives that will enhance the beneficial aspects of AI use and prevent farmers from risks, such as financial regulations for initial costs, and ethical frameworks.

In terms of training needs, farmers and entrepreneurs is not needed to have advanced AI education, but they should both have basic IT skills, soft skills such as communication and problem solving as well as green skills.

# Reflection Roundtable in Cyprus

## 1. Conclusion on the main aspects of the Roundtable

### AI use in agriculture, opportunities and risks.

Artificial Intelligence in Cyprus agriculture, it's only known through Horizon European programs. The only AI-application identified by the survey is classifying and identifying weeds in agricultural fields. None of the participants was aware of any agriculture company or individual that is using AI technology. In contrast with AI, the use of smart technology is more popular. Many farms are using robotic milking, satellites and different kind of sensors for monitoring crops.

The participants expressed their concern for the AI use in agriculture because as they mentioned agriculture sector has to do with life, it's a multifactorial sector and sometimes it can be an unpredictable environment with many parameters to consider, you can have many changes from year to year.
Also, they said that with a combination of different kind of technologies, such as satellites and sensors you could take the correct decisions on your own so why using AI?
Another issue they mentioned is that although there is a lot of technology in agricultural machinery sometimes it's not applicable in Cyprus due to the small-scale fields and farming that we have, could it be the same with AI?
The participants stated that agriculture sector in Cyprus faces a lot of challenges that needs to be addressed before adopting AI. But they also stated that AI is a new tool, and like smart technology could help us improve Cyprus agriculture.

Using AI, the participants mentioned that there is always the risk of misinformation and inaccuracies so the AI applications for agriculture should be compile and open to add new data and information continuously.

For the cost, the participants said that depending on the technology and application it can be expensive but also it can be affordable with smaller applications that are using simpler solutions.

About the role of age and educational level in AI use in agriculture, the participants said that if there is a will to learn, then with a small training it's feasible for older generation to use AI applications but in general older generation are not positive in adopting AI technologies unlike the younger generation who are more open to AI.

### Current training and policy needs

No current training programs in Cyprus were identified by the participants and no discussion made for policy needs.

### Comments on the Survey analysis results

The survey results were pretty much expected from the participants with no further comments.
They agreed with the last comment of the survey that in Cyprus we have not developed the tools - data based for decision making and we should do that first and then adopt the use of AI.

### Further demands expressed

Further suggestions were to continue having projects like AI4Agri so we can increase our knowledge of AI.

To have a collaboration between farmers, AI experts and all stakeholders so we can have good results that will take us far ahead.

Also mentioned is that the government should invest more in agriculture sector and support the adoption of new technologies and AI applications in order to improve Cyprus economy.

## 2. Summary

The following outcomes and results were obtained by the completion of Activity A.2.3 Reflection Roundtable:

- Cyprus is far behind in adopting AI technologies in agriculture.
- There is a lack of awareness, training and education for AI use.
- There is also lack of experts in the field of AI in agriculture.
- At the moment, in Cyprus there is not even demand for AI technologies in agriculture, most probably due to lack of knowledge.
- There is will for knowledge, training and education.

# Reflection Roundtable in Greece

## 1. Conclusion on the main aspects of the Roundtable

The Roundtable and survey analysis provided a comprehensive understanding of the challenges and opportunities related to AI adoption in Greek agriculture. The insights gathered highlight several key aspects:

The roundtable discussions and survey results emphasized the critical need for increased awareness and understanding of AI applications in agriculture. While some innovative examples and initiatives exist, the overall familiarity and use of AI among Greek agricultural workers and potential entrepreneurs remain low. This gap in knowledge and application underscores the urgent need for targeted interventions.

### AI Use in Agriculture, opportunities and risks

The participants recognized the significant potential of AI to transform agricultural practices, offering opportunities to improve efficiency, productivity, and environmental sustainability. Successful case studies from participants demonstrate the tangible benefits of integrating AI and IoT in agriculture. However, risks such as data privacy concerns, potential biases in AI applications, and high costs associated with AI adoption were also highlighted. The survey corroborates these concerns, with a substantial portion of respondents citing the complexity and cost of AI technologies as major barriers.

### Current training and policy needs

There is a clear and pressing need for customized training programs that focus on practical, ROI-focused applications of AI in agriculture. The roundtable and survey findings revealed a significant skill gap among agricultural workers and entrepreneurs, emphasizing the need for accessible and tailored educational resources. Moreover, participants called for supportive policies that facilitate technological innovation and provide financial incentives for farmers to invest in AI. The survey indicated that a large majority of respondents were unaware of existing government initiatives promoting digitalisation and AI in agriculture, pointing to a need for better communication and outreach.

### Comments on the Survey analysis results

The survey results provided a valuable data-driven foundation for the discussions. Key findings included low familiarity with AI among respondents, the significant barriers posed by costs and technical complexity, and the lack of awareness about government support programs. These insights aligned closely with the experiences and observations shared by Roundtable participants, reinforcing the validity of the survey data and highlighting areas for targeted intervention.

### Further demands expressed

Participants expressed a demand for more local initiatives and stronger support from the Greek government and other stakeholders. They highlighted the importance of seeking funding and IT opportunities from Europe and private investors to drive AI adoption in agriculture. There was also a call for better infrastructure, particularly in terms of internet connectivity, to enable farmers to leverage digital technologies effectively.

## 2. Summary

The Roundtable and survey provided several key takeaways:

- **Awareness and Education**: Increasing awareness and providing education on AI applications in agriculture are paramount. Practical, hands-on training programs that demonstrate clear benefits and ROI are essential.
- **Infrastructure and Accessibility**: Improving infrastructure, especially internet connectivity, is crucial for enabling the adoption of AI technologies.
- **Supportive Policies**: There is a need for policies that support technological innovation, provide financial incentives, and facilitate access to funding and technical assistance.
- **Motivation and Inspiration**: Targeted efforts to motivate and inspire farmers, especially younger generations, can significantly boost AI adoption.

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