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AI and new business models in agriculture: the ZERO case study

Supervisor

Ch. ma Prof.ssa Francesca Dal Mas

Graduand

Alberto Cavazza

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"Innovation is based on the ability to transgress."

Umberto Veronesi

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Introduction

Artificial intelligence (AI) is a growing technology that is attracting the interest of both academics and practitioners (Arora et al., 2022; Dal Mas et al., 2021). Several definitions of AI have been given periodically, redefining the concept according to the latest advancements. For instance, W Boers et al., n.d. defined it as "an area of study in the field of computer science concerned with the development of computers able to engage in human-like thought processes such as learning, reasoning, and self-correction" (page 2).

While AI is widely employed in several fields, for instance, healthcare uses AI to improve clinical decision-making, facilitate disease diagnosis and assist in surgical intervention for various human diseases, bringing clinical experts to remote regions (Yu et al., 2018), while in the banking sector AI is widely diffused for bank productivity evaluation, bank stress testing and bank distress forecasting (Doumpos et al., 2022). In the aviation sector, AI has several areas of use such as improving decision-making in critical situations with a great amount of accumulated information, optimization of flight routes of aircraft in the airport area and success of means for detecting and preventing collisions between aircraft and unmanned aerial systems (Kulida & Lebedev, 2020). In the hospitality sector AI improve the customer service and experience transforming a high-touch sector in a high-tech sector (Goel et al., 2022). Just in the last periods AI is widely spoken around the world for the ChatGpt case, a new powerful language model developed by Open AI able to understand and generate human-like text with remarkable accuracy which can revolutionize the actual market with several applications in academic writing, coding, and social media marketing (Aljanabi et al., 2023). Our focus is addressed on Agritech, defined by Moro-Visconti & Visconti, n.d. as "the use of technology in agriculture, horticulture, and aquaculture to improve yield, efficiency, and profitability." (Page 2)

AI in the Agritech field includes the use of innovative technologies such as field sensors, drones, farm management software, automated machinery, or water and fertilizer management solutions. In this category, we may also include new innovative farming techniques such as vertical farming, aquaculture, and insect breeding (Moro-Visconti & Visconti, n.d.).

At the global level, the agricultural sector has a value of 3,6 trillion dollars, providing 4% of the global gross domestic product (GDP) with a stable measure during the last twenty years. Moreover, in some developing countries, it accounts for more than 25% of GDP

(Agriculture and Food, 2022). It is a food and energy base of the new economy, especially because it ensures food security (Magasumovna et al., 2017).

Different implicit problems have been historically challenging the agricultural sector. The first of such issues is undoubtedly the number of workers which is significantly collapsed with a progressive difficult-to-employ workforce. For instance, between 2000 and 2022 the global workforce employed in agriculture collapsed from 40% to 27%, representing a reduction of 177 million people (World Food and Agriculture – Statistical Yearbook 2022, 2022). In these data, we can capture the technological impact in this field in the last century, with a food production increment per person less than proportional with the population growth; this last more than doubled between 1950 and 1998 (Sunding & Zilberman, 2001).

In the last years, there has been a similar trend with an increasing population but decreasing productivity caused by climate change and desertification, with a decline of 134 million hectares of cultivated land between 2000 and 2020 (World Food and Agriculture – Statistical Yearbook 2022, 2022). For these reasons, sustainably achieving food security is one of the objectives included in the United Nations (UN) 2030 sustainable goals with the ZERO-hunger program. According to World Food and Agriculture – Statistical Yearbook 2022, 2022, in 2021 770 million people were undernourished, with an increment of 150 million from 2020 (Wijerathna-Yapa & Pathirana, 2022).

Innovation technology, digitalization, and AI could represent some of the ways to achieve sustainability goals and manage the climate change challenge (di Vaio et al., 2020). For this reason, we have focused our research on the opportunity to address some of the cited problems creating new sustainable business models in the agricultural sector using AI as a disruptive technology.

The digital revolution has already changed the world where we live, but only in the last years the agricultural sector has started to understand the need to integrate information and communication technologies in traditional farming to improve crop yield efficiency, reduce costs and optimize process inputs with the usage of data (Boursianis et al., 2022). For this reason, in our analysis, we have focused on the actual situation of the Agritech trying to better understand the future perspectives, barriers and implementations with the focus on the possibility of AI to disrupt the actual business model in the agricultural sector creating new ones.

In the second part of this analysis, we investigate the practical case of an Italian company located in Pordenone which has patented a new vertical farming modular architecture using massively AI. After a brief introduction to the market and the company, we interviewed the CEO of the company capturing in the practice an example of an agricultural business model driven by technology.

Chapter 1: Artificial Intelligence and new business models in Agriculture: a structured literature review

1.1. Methodology

This paper adopts a structured literature review defined by Massaro et al., 2016 as "a method for studying a corpus of scholarly literature, to develop insights, critical reflections, future research paths, and research questions". This approach "can help experienced scholars develop new and interesting research paths by accessing and analysing a considerable volume of scholarly work" (Massaro et al., 2016). We have prepared a literature review protocol to guide us during the analysis creating a framework to select, analyse and asses' papers with the aim of ensuring robust and defensible results through reliability and repeatability (Vaska et al., 2021). In the further step we defined the analytical framework and the search key which aim to bring new perceptions from the academic literature.

1.1.1 Write a literature review protocol and define the questions that the literature review is setting out to answer

A first preliminary protocol was identified to record the processes followed in assuming and in developing the literature review, and in making it repeatable and trustworthy. The study examines the following research question:

- RQ1: Can AI be a disruptive technology to create new business models in the agricultural sector?

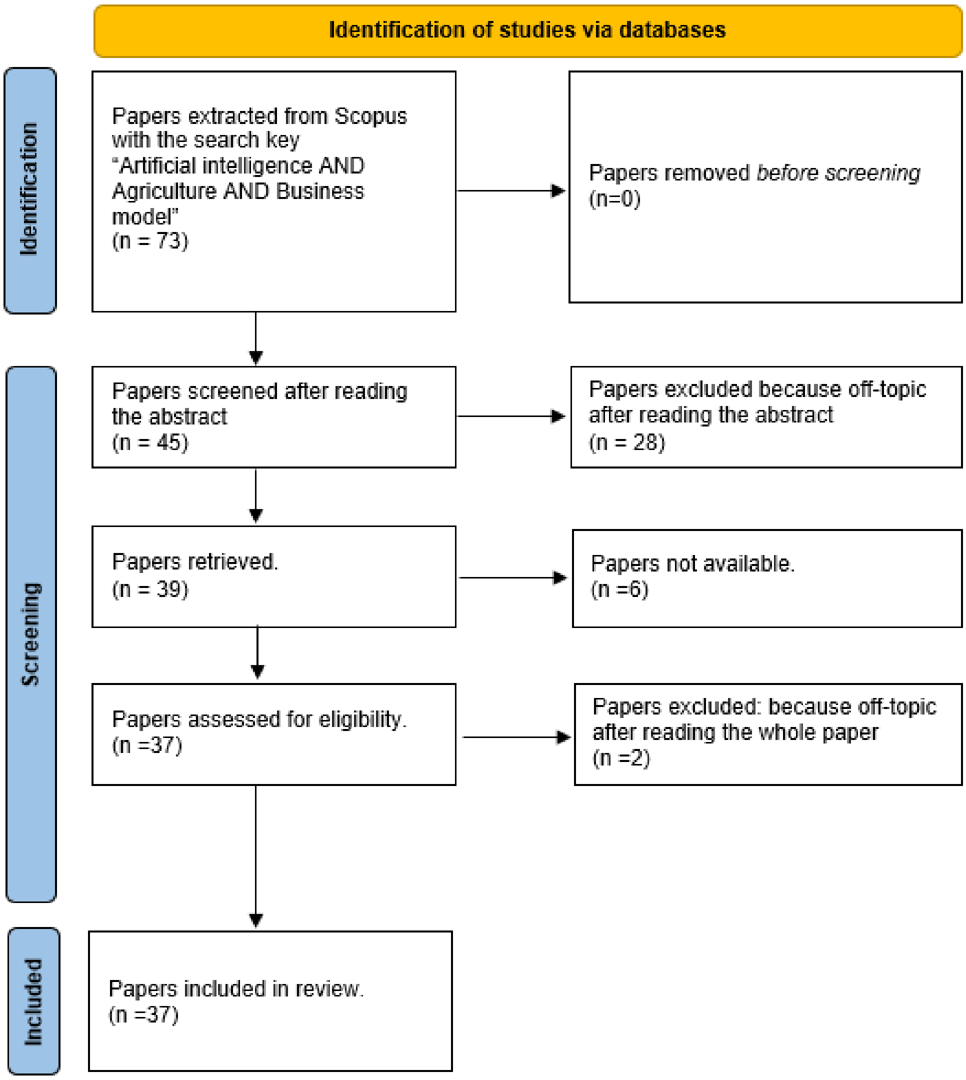
1.1.2 Determine the type of studies and carry out comprehensive literature research

We used the database Scopus to find relevant contributions to be analysed. The search key "Artificial intelligence AND Agriculture AND Business model" in the title, abstract, or keywords, conducted on September 13th, 2022, led to 73 total contributions. Of those 73 between journal papers and conferences, 45 have been considered appropriate for the analysis while 28 have been considered off-topic. Of these, 6 sources have not been retrieved, while the other 39 were coded using NVivo. During the codification process, 2 papers were excluded because off-topic after eligibility.

This work is intended to advance the knowledge about the possibility to lead new business models in the agricultural sector with the usage of AI as a disruptive technology, highlighting the actual situation, the main benefits, and barriers and identifying new avenues for research and practitioners (Vaska et al., 2021).

The following Figure 1.1 reports the selection process following (Page et al., 2021).

Fig. 1.1. Process of article selection following the PRISMA methodology



Source: The Authors following (M. J. Page et al., 2021).

1.2. Results

The following Table 1.1 reports the bibliographic details of the 37 articles and conference proceedings which were included in the literature review. While the earliest work is dated back to 2005, twenty-four contributions (65% of the total sample) were published after 2017, highlighting the increasing interest in this topic in the last few years.

Tab. 1.1. Bibliographic details of the included works.

#	Authors	Title	Year	Source Title	Ref
1	Ahmed M., Hayat R., Ahmad M., ul-Hassan M., Kheir A.M.S., ul-Hassan F., ur-Rehman M.H., Shaheen F.A., Raza M.A., Ahmad S.	Impact of Climate Change on Dryland Agricultural Systems: A Review of Current Status, Potentials, and Further Work Need	2022	International Journal of Plant Production	(Ahmed et al., 2022)
2	Gargiulo J.I., Lyons N.A., Clark C.E.F., Garcia S.C.	The AMS Integrated Management Model: A decision-support system for automatic milking systems	2022	Computers and Electronics in Agriculture	(Gargiulo et al., 2022)
3	Li H., Li S., Yu J., Han Y., Dong A.	AIoT Platform Design Based on Front and Rear End Separation Architecture for Smart Agricultural	2022	ACM International Conference Proceeding Series	(H. Li et al., 2022)
4	Kassanuk T., Phasinam K.	Impact of Internet of Things and Machine Learning in Smart Agriculture	2022	ECS Transactions	(Kassanuk & Phasinam, 2022)
5	Ahamed N.N., Vignesh R.	Smart Agriculture and Food Industry with Blockchain and Artificial Intelligence	2022	Journal of Computer Science	(Ahamed & Vignesh, 2022)

6	Chiles R.M., Broad G., Gagnon M., Negowetti N., Glenna L., Griffin M.A.M., Tami-Barrera L., Baker S., Beck K.	Democratizing Ownership and participation in the 4th Industrial Revolution: challenges and opportunities in cellular agriculture	2021	Agriculture and Human Values	(Chiles et al., 2021)
7	Mohr S., Kühl R.	Acceptance of artificial intelligence in German agriculture: an application of the technology acceptance model and the theory of planned behavior	2021	Precision Agriculture	(Mohr & Kühl, 2021)
8	Khan N., Kamaruddin M.A., Sheikh U.U., Yusup Y., Bakht M.P.	Oil palm and machine learning: Reviewing one decade of ideas, innovations, applications, and gaps	2021	Agriculture (Switzerland)	(Khan et al., 2021)
9	Bakhtadze N., Maximov E., Maximova N.	Local Wheat Price Prediction Models	2021	2021 7th International Conference on Control Science and Systems Engineering, ICCSSE 2021	(Bakhtadze et al., 2021)
10	Eashwar S., Chawla P.	Evolution of Agritech Business 4.0 - Architecture and Future Research Directions	2021	IOP Conference Series: Earth and Environmental Science	(Eashwar & Chawla, 2021)
11	Bogomolov A., Nevezhin V.,	Review of digital technologies in agriculture as a factor that	2021	E3S Web of Conferences	(Bogomolov et al., 2021)

	Larionova M., Piskun E.	removes the growth limits to human civilization			
12	Sood A., Sharma R.K., Bhardwaj A.K.	Artificial intelligence research in agriculture: a review	2021	Online Information Review	(Sood et al., n.d.)
13	Wakjira K., Negera T., Zacepins A., Kviesis A., Komasilovs V., Fiedler S., Kirchner S., Hensel O., Purnomo D., Nawawi M., Paramita A., Rachman O.F., Pratama A., Faizah N.A., Lemma M., Schaedlich S., Zur A., Sper M., Proschek K., Gratzer K., Brodschneider R.	Smart apiculture management services for developing countries—the case of SAMS project in Ethiopia and Indonesia	2021	PeerJ Computer Science	(Wakjira et al., 2021)
14	Panpatte S., Ganeshkumar C.	Artificial Intelligence in Agriculture Sector: Case Study of Blue River Technology	2021	Lecture Notes in Networks and Systems	(Panpatte & Ganeshkuma r, 2021)
15	Choi J., Koshizuka N.	Optimal Harvest date Prediction by Integrating Past and Future Feature Variables	2019	2019 IEEE Asia-Pacific Conference on Computer Science and	(Choi & Koshizuka, 2019)

				Data Engineering, CSDE 2019	
16	Backman J., Linkolehto R., Koistinen M., Nikander J., Ronkainen A., Kaivosoja J., Suomi P., Pesonen L.	Cropinfra research data collection platform for ISO 11783 compatible and retrofit farm equipment	2019	Computers and Electronics in Agriculture	(Backman et al., 2019)
17	Thomas D.T., Mitchell P.J., Zurcher E.J., Herrmann N.I., Pasanen J., Sharman C., Henry D.A.	Pasture API: A digital platform to support grazing management for southern Australia	2019	23rd International Congress on Modelling and Simulation - Supporting Evidence-Based Decision Making: The Role of Modelling and Simulation, MODSIM 2019	(Thomas et al., 2019)
18	Skobelev P., Larukchin V., Mayorov I., Simonova E., Yalovenko O.	Smart Farming – Open Multi-agent Platform and Eco-System of Smart Services for Precision Farming	2019	Lecture Notes in Computer Science (including subseries Lecture	(Skobelev et al., 2019)

				Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	
19	Kamariotou M., Kitsios F., Madas M., Manthou V., Vlachopoulou M.	Strategic Decision Making and Information Management in the Agrifood Sector	2019	Communications in Computer and Information Science	(Kamariotou et al., 2019)
20	Sahu S., Chawla M., Khare N.	Viable crop prediction scenario in bigdata using a novel approach	2019	Advances in Intelligent Systems and Computing	(Sahu et al., 2019)
21	Balaji Prabhu B.V., Dakshayini M.	Performance Analysis of the Regression and Time Series Predictive Models using Parallel Implementation for Agricultural Data	2018	Procedia Computer Science	(Balaji Prabhu & Dakshayini, 2018)
22	Rao M., Chhabria R., Gunasekaran A., Mandal P.	Improving competitiveness through performance evaluation using the APC model: A case in micro-irrigation	2018	International Journal of Production Economics	(Rao et al., 2018)
23	Li J., Gao H., Liu Y.	Requirement analysis for the one-stop logistics management of fresh agricultural products	2017	Journal of Physics: Conference Series	(J. Li et al., 2017)
24	Wolfert S., Ge L., Verdouw C., Bogaardt M.-J.	Big Data in Smart Farming – A review	2017	Agricultural Systems	(Wolfert et al., 2017)

25	Nada A., Nasr M., Salah M.	Service oriented approach for decision support systems	2014	2014 IEEE 7th Joint Internationa l Information Technology and Artificial Intelligence Conference, ITAIC 2014	(Nada et al., 2014)
26	Vizzari M., Modica G.	Environmental effectiveness of swine sewage management: A multicriteria ahp-based model for a reliable quick assessment	2013	Environmen tal Management	(Vizzari & Modica, 2013)
27	Lima M.L., Romanelli A., Massone H.E.	Decision support model for assessing aquifer pollution hazard and prioritizing groundwater resources management in the wet Pampa plain, Argentina	2013	Environmen tal Monitoring and Assessment	(Lima et al., 2013)
28	Le Page M., Berjamy B., Fakir Y., Bourgin F., Jarlan L., Abourida A., Benrhanem M., Jacob G., Huber M., Sghrer F., Simonneaux V., Chehbouni G.	An Integrated DSS for Groundwater Management Based on Remote Sensing. The Case of a Semi-arid Aquifer in Morocco	2012	Water Resources Management	(M. le Page et al., 2012)
29	Deng J., Chen X., Du Z., Zhang Y.	Soil Water Simulation and Predication Using Stochastic Models Based on LS-SVM for Red Soil Region of China	2011	Water Resources Management	(Deng et al., 2011)

30	Carmona G., Varela-Ortega C., Bromley J.	The Use of Participatory Object-Oriented Bayesian Networks and Agro-Economic Models for Groundwater Management in Spain	2011	Water Resources Management	(Carmona et al., 2011)
31	Tironi A., Marin V.H., Campuzano F.J.	A management tool for assessing aquaculture environmental impacts in Chilean Patagonian fjords: Integrating hydrodynamic and pellets dispersion models	2010	Environmental Management	(Tironi et al., 2010)
32	Manos B.D., Papathanasiou J., Bournaris T., Voudouris K.	A DSS for sustainable development and environmental protection of agricultural regions	2010	Environmental Monitoring and Assessment	(Manos et al., 2010)
33	d'Orgeval T., Boulanger J.-P., Capalbo M.J., Guevara E., Penalba O., Meira S.	Yield estimation and sowing date optimization based on seasonal climate information in the three CLARIS sites	2010	Climatic Change	(d'Orgeval et al., 2010)
34	Wang H., Zhang X., Wang W., Zheng Y.	Research and implement of maize variety promotion decision support system based on WebGIS	2009	IFIP International Federation for Information Processing	(Wang et al., 2009)
35	Nangia V., Turral H., Molden D.	Increasing water productivity with improved N fertilizer management	2008	Irrigation and Drainage Systems	(Nangia et al., 2008)
36	Cabrera V.E., Breuer N.E., Hildebrand P.E.	Participatory modelling in dairy farm systems: A method for building consensual	2008	Climatic Change	(Cabrera et al., 2008)

		environmental sustainability using seasonal climate forecasts			
37	Diaz B., Ribeiro A., Bueno R., Guinea D., Barroso J., Ruiz D., Fernadez-Quintanilla C.	Modelling wild-oat density in terms of soil factors: A machine learning approach	2005	Precision Agriculture	(Diaz et al., n.d.)

Source: Our elaboration (2023).

Several nodes were gathered from previous studies, while others were decided following an extensive discussion among the authors, considering the specific field of investigation.

The first node refers to the type of authors dividing them between academics, collaborations, and practitioners (Dal Mas et al., 2020). The second node refers to the type of source discriminating articles and conferences. The third node refers to the location where the study is conducted, grouping countries by continent (Dal Mas et al., 2020; Massaro et al., 2015). The fourth group of nodes refers to the research method dividing sources between case studies and literature reviews (Massaro et al., 2015; Paoloni et al., 2020).The fifth node refers to the agricultural sector, while the sixth category concerns the problems to solve and the objective to reach. In this last node, the sub-nodes were added while coding the papers. The seventh node analyses the technology used and cited in the studies. The eighth node group maps the application in agriculture, while the ninth node focuses on identifying sources which treat a business model. In the seventh and eighth nodes, the sub-nodes were added while coding the papers. The ninth node is about the eventual possibility to lead a new business model. The tenth node analyses the eventual connection with sustainability issues. The eleventh node maps the presence of a given definition of AI. Last but not least, the last three nodes refer to the presence of research, practice, and policy implications. (Dal Mas et al., 2020).

The following Table 1.2 underlines the results of the NVivo coding, following the framework.

Tab. 1.2. The Analytical framework.

Category	Variables	Results	%
Authors		37	
	Academics	25	67%
	Collaborations	8	22%
	Practitioners	4	11%
Type of source		37	
	Article	21	57%
	Conference	16	43%
Location of the study		37	
	Yes	24	65%
	- Asia	11	46%
	- America	7	29%
	- Europe	6	24%
	- Oceania	2	8%
	- Africa	2	8%
	No	13	35%
Research method		37	
	Case study	26	70%
	Literature review	11	30%
Agricultural sector		37	
	Cultivation of plants	15	40%
	General terms	15	40%
	Animal production	6	16%
	Fish farming	1	3%
Problems to solve-objective to achieve		37	
	Increase efficiency and optimization maximizing farm returns	26	70%

	Manage the environmental impact and external changes	24	65%
	Predict and manage the farm complexity	19	51%
	Feed the increasing global population-food security	9	24%
	Other objectives	2	5%
Technology used		37	
	Decision support system (DSS)	21	57%
	Artificial intelligence and machine learning	18	49%
	Big data analytics	16	43%
	Internet of things (IoT)	15	40%
	Drones	8	22%
	Robots	8	22%
	Cloud computing	7	19%
	Geographical indication system (GIS)	6	16%
	Other technologies	6	16%
	Biotechnology	4	11%
	Blockchain	3	8%
	Autonomous devices	3	8%
Applications in agriculture		37	
	Precision farming and agronomic applications	24	65%
	Agronomic planning and economic applications	21	57%
	Water optimization and environmental management applications	15	40%
	Food supply chain applications and Traceability	5	14%
Mentions a business model		37	
	No	20	54%
	Yes	17	46%
	- Smart farming Business model	13	76%
	- Data-driven business model	8	47%
	- Industry 4.0 business model	2	15%

Mentions the possibility to lead a new business model		37	
	No	31	84%
	Yes	6	16%
	- Platform business model in the food supply chain	2	33%
	- Agritech 4.0 with integrated smart food supply chain	2	33%
	- Supply chain management 5.0	1	17%
	- New information-based system based on traceability	1	17%
Connects to sustainability issues		37	
	Yes	23	62%
	- Reduce the use of pesticides, heavy metals and nitrates which pollute agricultural soil and water	8	35%
	- Reduce the consumption and loss of water	6	26%
	- Climate-oriented and ecologically friendly applications	5	22%
	- Food security in a sustainable way	5	22%
	- Making sustainable the ecological impact of food production	4	17%
	No	14	38%
Definition of AI in agriculture		37	
	No	35	95%
	Yes	2	5%

Explain the advantages		37	
	Yes	34	92%
	- Organizational advantages and decision support	24	71%
	- Efficiency benefits and productivity increase	16	47%
	- Environmental benefits	2	6%
	- Food safety and easy compliance	2	6%
	No	3	8%
Explain the disadvantages		37	
	No	30	81%
	Yes	7	19%
	- The water limits compliance inevitably leads to some losses in the farm income	1	14%
	- The system doesn't work without a standard power supply	1	14%
	- Some will always think that is absurd, disappointing, and dangerous for humankind	1	14%
	- Difficult to create a unique system for different areas and crops	1	14%
	- Inevitable carbon dioxide emission as a consequence of the intensive use of information technologies	1	14%
	- Environmental impact in the food chain from genetically engineered crops which will destroy the actual situation	1	14%
	- Complexity to realize	1	14%

	- Unrealizability on areas without extensive available data regarding soil and geology	1	14%
Explain the barriers		37	
	No	23	62%
	Yes	14	38%
	- Farmers lack technical knowledge about ICT and other emerging technologies	7	50%
	- Lack of equipment, internet access, storage capacity and high-quality data	7	50%
	- High investment costs and low perceived effectiveness	6	43%
	- Mismatch between applications and farmer practical needs	4	29%
	- Data control and data security	3	21%
	- Lack of integration and complexity of the food supply chain	2	14%
	- Large energy consumption and unsustainability	2	14%
	- User psychological barriers to adoption	1	7%
Open issues		37	
	No	34	8%
	Yes	3	92%
	- How to feed the increasing global population sustainably?	1	33%
	- How to practically organize the Agritech 4.0 food supply chain using new integrated technologies	1	33%
	- How the potential of information across food systems can be utilized	1	33%

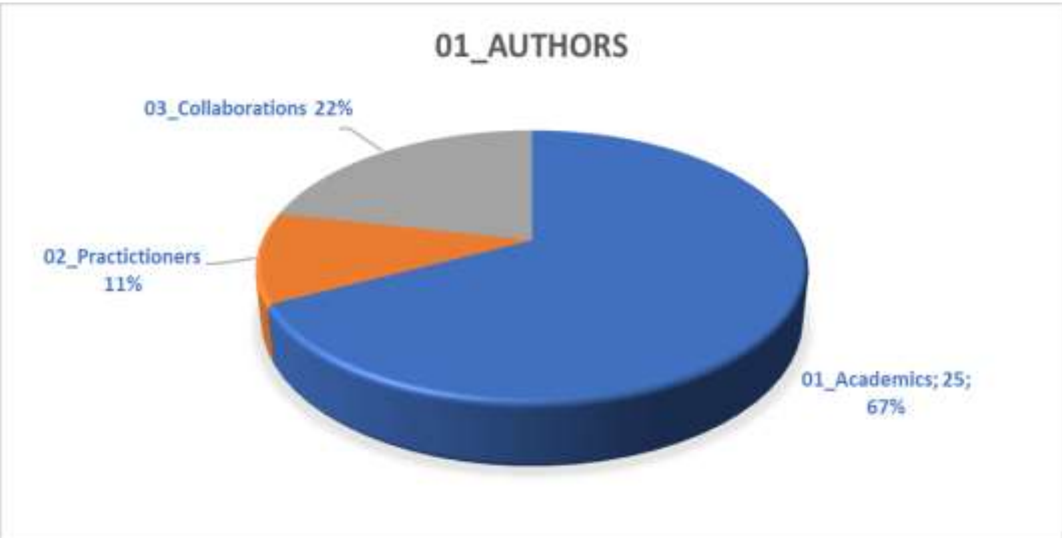
Research implications		37	
	No	21	57%
	Yes	16	43%
	- Extend and integrate the research with new data or focus on new related problems	10	62%
	- Test the validity and accuracy of the proposed method	4	25%
	- Focus on new aspects not yet deepened	3	19%
	- Focus on developing new solutions and new technologies	3	19%
Practical implications		37	
	Yes	26	70%
	- Support farmers in the decision-making process	13	35%
	- Support everyday farm operations increasing efficiency and effectiveness	10	27%
	- Provide farmers useful forecasts to manage the farm unpredictability by planning their activity	7	19%
	- Provide farmers with new solutions with integrated technologies	3	8%
	No	11	30%
Policy implications		37	
	No	28	76%
	Yes	9	24%
	- Governments should use agricultural data to improve policy-making and decision-making learning from data	4	44%

	- Governments should subscribe new investments to enhance the technological transition	4	44%
	- Governments should create advisory units to support the farmer's awareness of complex technological tasks.	2	22%
	- Governments should support social innovation to engage younger generations to be more involved in the honey and bee industry	1	11%

Source: our elaboration (2023).

Concerning the node "authors", it can be underlined how the authors are mainly represented by academics with twenty-five contributions. Interestingly, eight works are the outcome of a collaboration between scholars and practitioners. Finally, five articles are authored by practitioners, mainly belonging to institutional agricultural research centres. The following Figure 1.2 reports the author's node results.

Fig. 1.2 The authors

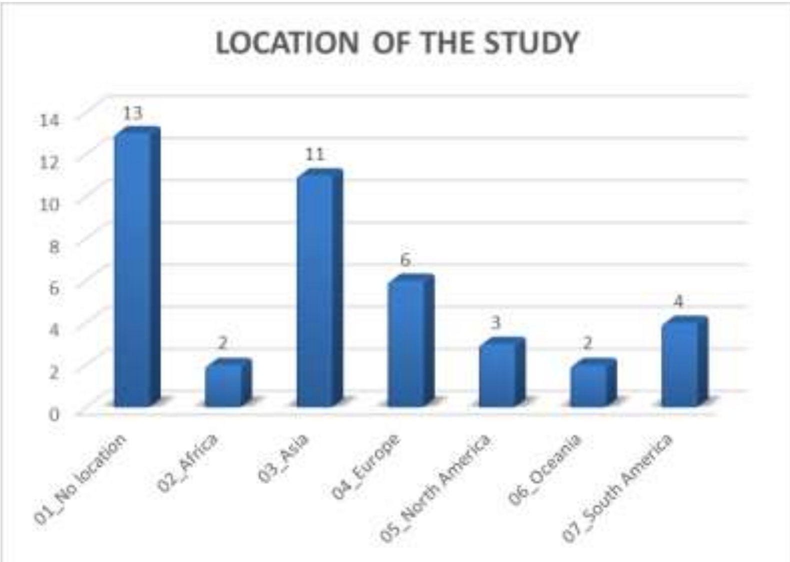


Source: our elaboration (2023).

Twenty-one sources are represented by journal articles, while sixteen are conference papers.

Concerning the location of the study, twenty-four sources specify the location where the investigation was conducted, while thirteen papers have no specific location as they refer to specific technological solutions or algorithms. Considering the papers that do declare the location of their investigation, eleven sources are focused on Asia and seven on America (including both North and South America). Six sources refer to European cases, while Africa and Oceania have respectively two papers for each continent. However, there is not an absolute predominance. Therefore, we may claim that the sample is well representative around the world. The following Figure 1.3 reports the location of the study results while Table 1.3 explains the obtained countries on more detail.

Fig. 1.3 Location of the study



Source: our elaboration (2023).

Tab. 1.3 Location of the study

Location of the study		**37**
	No	13
	Yes	26
	Argentina	3
	China	3

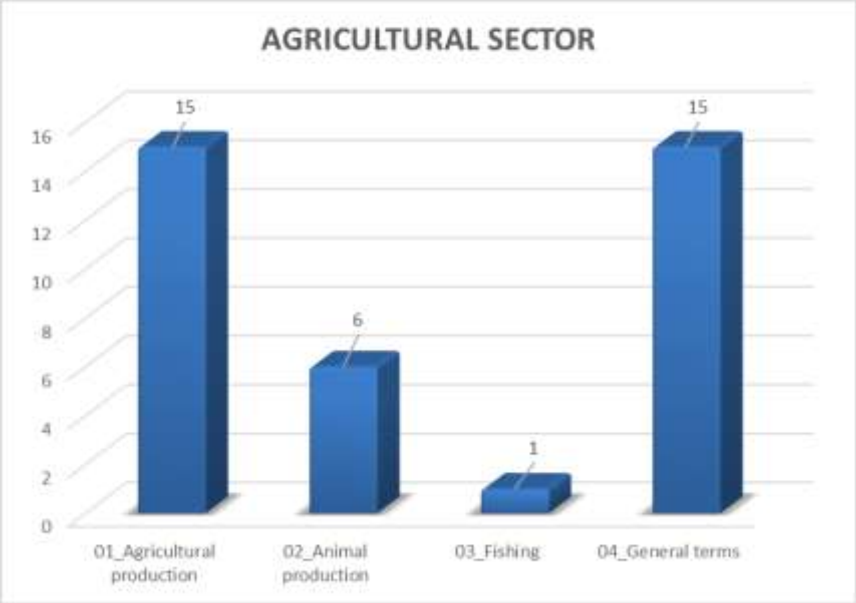
	Russia	3
	USA	3
	Spain	2
	Chile	2
	India	2
	Australia	2
	Ireland	1
	Ethiopia	1
	Indonesia	1
	Japan	1
	South Asia	1
	Italy	1
	Morocco	1
	Germany	1
	Greece	1
	New Zealand	1

Source: our elaboration (2023).

When referring to the research methodology, the vast majority of the sources (26 papers, equal to 70% of the total sample) are represented by case studies, while the remaining eleven papers are literature reviews. The formers are not only practical cases but, in this context, especially theoretical investigations which focus on a new technological application presentation and discussion.

Focusing on the agricultural sector, fifteen sources relate to the cultivation of plants, while some argue about the agricultural sector in general terms. Animal production is treated in six papers, while only one article discusses fish farming. All in all, there seems to be a good coverage of topics, which expresses the various interests both from general and specific research groups. The following Figure 1.4 reports the agricultural sector result while Table 1.4 explain in more detail the specific sector.

Fig. 1.4 Agricultural sector



Source: our elaboration (2023).

Tab 1.4 Agricultural sector

Agricultural sector		37
	Cultivation of plants	15
	General crop	4
	Maize	3
	Tomato	2
	Wheat	2
	Rice	1
	Red gram	1
	Chilly	1
	Soybean	1
	Mango trees	1
	Eggplant	1
	Banana	1
	Oil palm	1
	Wild oat	1
	Legumes	1
	General terms	15
	Animal production	6

	Pasture	2
	Bee	1
	Swine	1
	Fish farming	1
	Salmon	1

Source: our elaboration (2023).

Regarding the specific issues and problems that stimulated the analysis, the goal of a significant number of sources refers to increasing efficiency and maximizing the farm return, with twenty-six papers. The need to manage the environmental impact and the external changes are treated in twenty-four articles. Moreover, nineteen papers discuss the issue of predicting and managing farm complexity, but, at the same time, great relevance is given to the food-security problem, discussed in nine sources. Ahmed et al. 2022 are an example of this last problem. In the paper, the authors predict as climate change, especially global warming and decreasing temperatures, could put half of the global population in trouble as a consequence of the declined crop productivity. Only two articles report other objectives. The different types of issues are strictly connected, with some articles arguing about more problems together. As an example, managing farm's complexity may lead to an increase in efficiency and profitability, creating a sort of turbo effect. For instance, Bogomolov et al., 2021 highlight the connection between the need to improve yields with the desertification problem and the related reduction of pesticides. The following Table 1.5 describes on more detail each sub-node with more specific problems to take into consideration.

Tab 1.5. Problems to solve and objective to achieve.

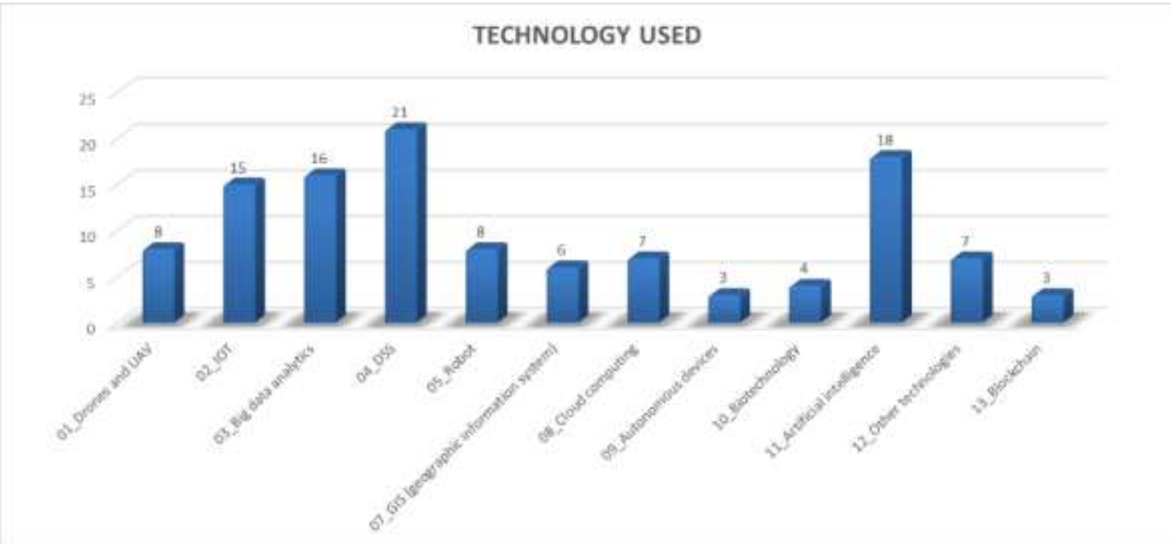
Problems to solve-Objectives to achieve		37
	Increase efficiency and maximise the farm return	26
	Yields improvement and optimization	15
	Optimal water management	12

	Manage the new customer demand	6
	Reduction of losses in the agrifood chain	4
	Inefficiency of manual monitoring and time-savings	4
	Manage the environmental impact and external changes	24
	Desertification, lack of fertility soil and scarcity of land	14
	Climate change and environmental management	8
	Reduce the environmental impact and avoid contamination of land and sea	6
	Reduce the usage of insecticides and pesticides	4
	Weed control	3
	Bees' colony losses	1
	Promoting and introducing new varieties of crops	1
	Predict and manage the farm complexity	19
	Manage the farm complexity increasing efficiency and predictability	11
	Simulate physical scenario	9
	Crop disease detection	4
	Optimal sowing date prediction	2
	Prevision of optimal harvest date	2
	Feed the increasing global population-food security	9
	Other objectives	2
	Lack of fertilizers in some developing countries	1
	Realize an inclusive ownership and participation strategy with equitable outcomes in the market	1

Source: our elaboration (2023).

Concerning the technologies that are mentioned within the papers, a significant number of sources treat Decision Support Systems (DSS), which stands as the most present technology. Only nineteen articles specifically refer about AI and Machine Learning. Other technologies with great relevance that are reported in the articles are represented by Big Data Analytics and the Internet of Things, with respectively sixteen and fifteen references. Other less discussed technologies are represented by drones and robots with eight papers each, cloud computing with seven articles, geographical indication systems and other technologies with six sources. Finally, biotechnology is treated on three occasions, while blockchain and autonomous devices are related to only three papers. Although the research has been based on AI as the leading keyword, the selected articles report several kinds of technologies, given their outstanding level of integration and complementarity. DSS is the most used technology because it represents the predecessor of AI. Indeed, by not limiting the time frame of our literature search, older resources prior to the new wave of AI refer to its antecedent DSS. However, within AI, we find all the sources which discuss Machine Learning and all its specialization, such as Artificial Neural Networks, Deep Learning, and so on. The following Figure 1.5 reports the technology used results while the Table 1.6 explains specifically the technology details.

Fig. 1.5 Technology used.



Source: our elaboration (2023).

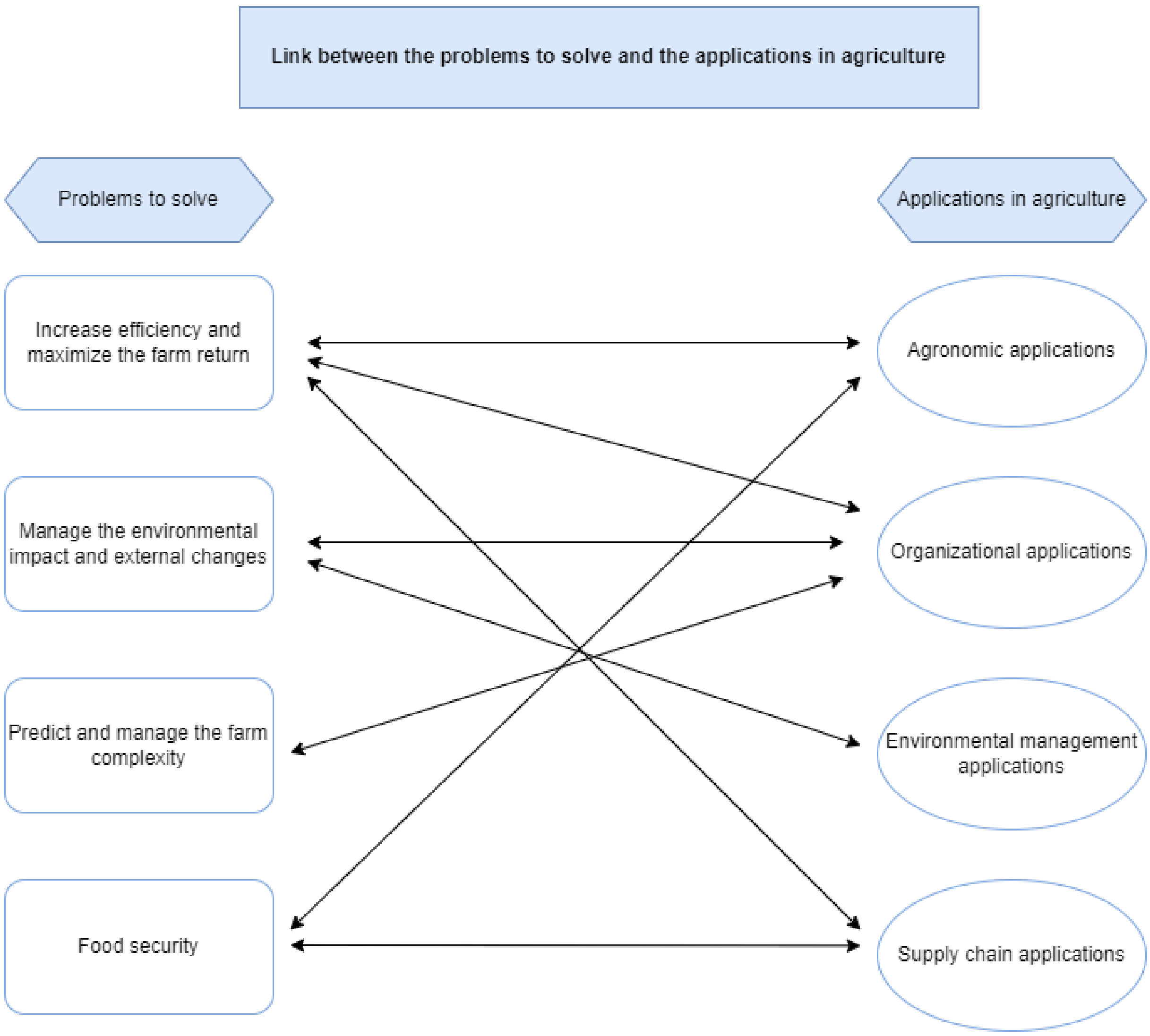
Tab. 1.6 Technology used.

Technology used		37
	Decision support system (DSS)	21
	Artificial intelligence and machine learning	18
	AI	15
	Machine learning	11
	Artificial Neural networks (ANN)	7
	Deep learning	5
	Support vector machine (SVM)	3
	Decision tree learning	2
	Convolutional neural network (CNN)	1
	Adaptive neuro-fuzzy inference system (ANFIS)	1
	Big data analytics	16
	Internet of Things (IoT)	15
	Drones	8
	UAV	3
	Robot	8
	Cloud computing	7
	Other technologies	7
	Face recognition	1
	Service-oriented approach (SOA)	1
	Radio frequency identification (RFID)	1
	Micro-irrigation	1
	Nanotechnologies	1
	Cellular agriculture	1
	Genetic algorithms	1
	Geographical information system (GIS)	6
	Biotechnology	4
	Blockchain	3
	Smart digital ledger technology (DLT)	1
	Autonomous devices	3

Source: our elaboration (2023).

The node application in agriculture allowed us to investigate the proposed applications in the agriculture field, leading to four main results. The first and the most treated is precision farming and other types of agronomic applications discussed in twenty-four papers. Agronomic planning and economic applications are reported by twenty-one sources. Less common applications are represented by water optimization with environmental management, and the supply chain applications with traceability systems, which are discussed respectively in fifteen and five papers. There seems to be a link between the applications and the problems to solve; the former tries to find feasible solutions by employing innovative and practical ways, and the following Table 1.7 explains these relationships. For instance, H. Li et al., 2022 propose an AIOT (Artificial Internet of Things) which permits to obtain crop growth parameters in real time, supporting the farmers in managing the farm complexity and unpredictability. Furthermore, the proposed solution makes intelligent recommendations for fertilization, crop disease detection and irrigation optimization. Another example is represented by Skobelev et al., 2019 who offer several precision farming solutions to increase productivity and efficiency of crop production, moreover, they reduce costs along the chain of production.

Fig. 1.7 Link between problems to solve and applications in agriculture.



Source: our elaboration (2023).

The following Table 1.7 reports the applications in agriculture on more detail.

Tab. 1.7 Application in agriculture.

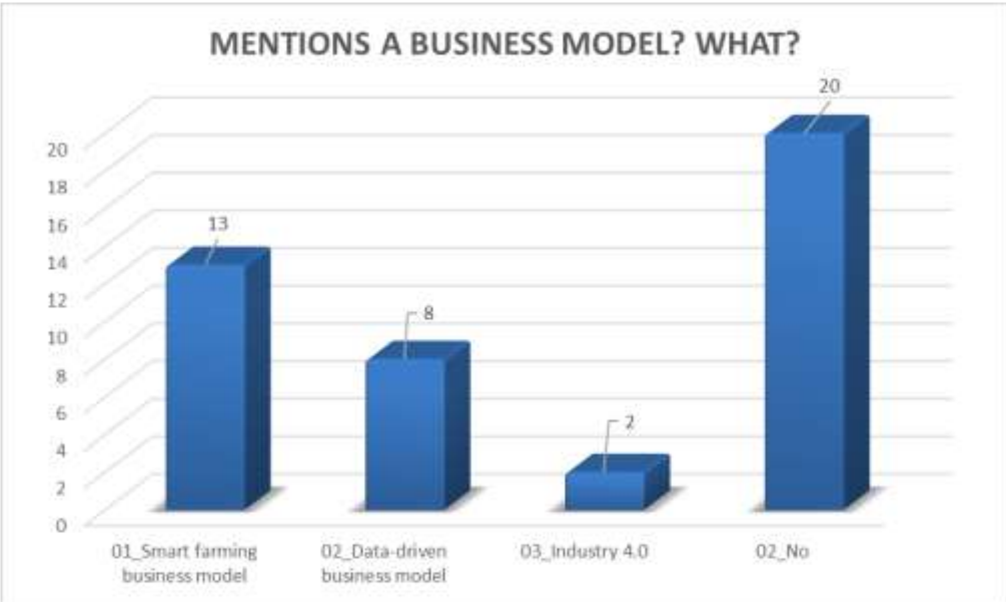
Applications in agriculture		37
	Precision farming and agronomic applications	24
	Precision farming	12
	Remote sensing for monitoring and tracking	9
	Seed selection	8

	Land allocation and soil classification	7
	Crop disease diagnosis	4
	Fertilization management	3
	Drive real-time operational decisions	3
	Optimal application of nitrogen maintaining the balance	2
	Genetic modifications of crops	1
	Abnormal alarm function with alarm autonomous decision-making	1
	Creation of hydrodynamic model capable of reproducing the dynamics of a Patagonian fjords	1
	Agronomic planning and economic applications	21
	Make optimal simulations with different scenarios	14
	Crop yield and growth rate prediction	11
	Increase crop efficiency and productivity	6
	Predict milk harvesting	2
	Forecast the demand, supply, and price of agricultural commodities	2
	Adaptation and disaster risk management planning	1
	Develop an inclusive innovation system	1
	Redesign agricultural business processes for game-changing business models	1
	Water optimization and environmental management	15
	Irrigation efficiency and reducing water wastage	12
	Prediction of agricultural activity impacts on groundwater resources	2
	Pursue ecologic safety and economic sustainability	1
	Manage the environmental issues connected to livestock production	1
	Food supply chain applications and traceability	5
	Traceability along the food supply chain	2
	Smart and integrated food supply chain	2
	Reducing costs along the whole chain of production	2
	Support effective decision-making in logistics	1

Source: our elaboration (2023).

One of the critical points of the analysis was to understand the type of business models reported by the articles as a consequence of the application of AI in agriculture. Interestingly enough, despite mentioning the words "Business model" either in the title, abstract, and/or keywords, the majority of the sources do not mention any kind of business model. Indeed, only seventeen papers (equal to 46% of the total sample) responded positively to this question. Among such seventeen sources, the most discussed business model is surely represented by smart farming with thirteen articles, followed by a data-driven business model with eight papers and, finally, the general industry 4.0 business model with only two sources. However, the findings are very connected to each other because both data-driven and smart farming are part of the more inclusive industry 4.0 business models which permit to enhance the value proposition, solve critical factors, and deliver meaningful experiences to customers. (Bagnoli et al., 2022; Pietrewicz, 2019). The following Figure 1.8 reports the business model mentions.

Fig. 1.8 Mentions a business model.



Source: our elaboration (2023).

The following node is connected to the previous one, investigating the possibility for AI to lead to a new business model. Again, the majority of the articles do not mention any type of new business model, with only six papers trying to address such a challenge. Among these articles, two sources propose a platform business model used for the food supply chain where the key participants of agriculture industry can sell and offer their products and services with the use of smart contracts, moreover they can exchange data enriching a common dataset (Skobelev et al., 2019; Sood et al., n.d.). The same number of sources propose an Agritech 4.0 business model with an integrated food supply chain where the new technologies permit to integrate both food production and food distribution, ensuring transparency, traceability, and customer satisfaction. (Eashwar & Chawla, 2021; Wolfert et al., 2017). Finally, supply chain management 5.0 and new information-based systems based on traceability are treated respectively on one article per topic. The former proposed a new supply chain solution based on driverless autonomous vehicles for transporting and smart contracts with face recognition, while the second treated a new system based on recommended guidelines and documentation requirements for decision-making processes to ensure traceability along the chain (Ahamed & Vignesh, 2022; J. Li et al., 2017). However, an interesting consideration is that all four new solutions are inherent to the food supply chain and to the need to reduce complexity through technology integration. These efforts are addressed also to reduce global food waste along the food chain which according to a 2011 FAO report amounts to 1/3 of the global production (Food waste index report 2021, 2021)

Another point of analysis referred to a potential connection with sustainability issues. Interestingly, most articles discuss sustainability issues, with only fourteen articles not considering any environmental nor social topics. Five different kinds of sustainability issues can be reported. The first and the most treated is the use of fertilizers, nitrates, and heavy metals, which pollute agricultural soil and water (eight references, equal to 35% of the total sample) and after the need to reduce the use and waste of water in the agricultural sector. The other topics are related to the need to produce climate-oriented and ecologically friendly applications, the need to achieve the food-security sustainably, and the need to make sustainable the production of some types of foods which heavily impact the environment. The following Table 1.8 analyses on more detail the sustainability issues connections.

Tab. 1.8 Connects to sustainability issues.

Connects to sustainability issues		
	Yes	23
	Reduce the use of pesticides, heavy metals and nitrates which pollute agricultural soil and water	8
	Reduce the consume and loss of water	6
	Climate-oriented and ecologically friendly applications	5
	Food security in a sustainable way	5
	End hunger, achieve food security promoting sustainable agriculture	4
	Increase production from existing farmland minimizing environmental pressure	2
	Increase yields without adverse environmental impacts	1
	Making sustainable the ecological impact of food	4
	Sustainability in the food production	1
	Change the actual palm oil cultivation into sustainable agriculture	1
	Making sustainable the salmon farming	1
	Making sustainable the livestock management production	1
	No	14

Source: our elaboration (2023).

In the investigation, a specific definition of AI in agriculture was sought. Notably, only two articles define AI, while all the other sources probably assume that the reader already knows the meaning, as they are written for a high-technical audience. The two definitions are reported in the following Table 1.9.

Tab. 1.9 Definition of artificial intelligence.

Paper	Definition
Soil Water Simulation and Predication Using Stochastic Models Based on LS-SVM for Red Soil Region of China (Deng et al., 2011)	Artificial intelligence is the area of computer science focusing on creating machines that can engage in behaviours that humans consider intelligent. Artificial intelligence machines describe the nonlinear relationship between inputs and outputs by training and testing from data to represent the behaviour of a system, including Artificial Neural Network (ANN), Adaptive Neuro-Fuzzy Inference System (ANFIS) and Support Vector Machine (SVM).
Impact of Climate Change on Dryland Agricultural Systems: A Review of Current Status, Potentials, and Further Work Need (Ahamed & Vignesh, 2022)	The field of Artificial Intelligence research characterizes itself as the investigation of" shrewd specialists," i.e., any gadget that sees its current circumstance, what's more, makes moves that augment its opportunity of accomplishment at some objective.

Source: our elaboration (2023).

Concerning the advantages gathered from the application of AI, almost all the sources (34 papers equal to 92% of the total sample) explain the benefits of the new technology implementations in the agricultural sectors. The most discussed advantages are represented by the organizational advantages and the decision-making support presented by twenty-four articles. Other advantages are related to the efficiency benefits and the productivity increase, while only two articles for each pro speak about environmental benefits and food-safety issues with the possibility to easily control food compliance. The following Table 1.10 reports the advantages in more detail.

Tab. 1.10 Explain the advantages.

Explain the advantages		
	Yes	
	Organizational advantages and decision support	
	Reduce the variability of economic and physical performance using sensitivity analysis with different inputs	11
	Minimize the environmental uncertainty and company risk under dynamic market changes	7
	Integration and storage of multiple data for tactical decision-making	7
	Support planning and simulation of seasonal outputs	6
	Support the decision about a variety type	2
	Quick and cost-effective predictions	2
	Participation of various stakeholders with a consequent increase in the effectiveness of the decision	2
	Use of a participatory model at a regional scale	2
	Permit to obtain the optimal harvest date	1
	Create an open research system based on connected agricultural data	1
	Efficiency benefits and productivity increase	16
	Efficiency and productivity increase	10
	Optimization of the exact amount of needed water and the exact timing	8
	Save time, increase efficiency, and ensure the customer trust about food	5

	Lessen exchange and implementation costs	1
	Environmental benefits	2
	Food safety and easy compliance	2
	Provide high levels of food safety based on the traceability along the food supply chain ensuring the authenticity of Agri inputs	1
	Easy verification of regulatory compliance along the food supply chain	1

Source: our elaboration (2023).

Another node is concern with ed the disadvantages. Interestingly enough, just a few articles (seven papers) discuss the cons, with the majority of the sources not discussing such issues. In our analysis, disadvantages are represented by negative consequences or shortcomings that can hardly be solved nor eliminated. Still some examples are represented by the inevitable loss of income related with the compliance with water restrictions for small vineyards farms or the fact that some irrigation decision-making systems are crop specific for a given area with a consequent great complexity to generalize the systems for other crops and other areas (Carmona et al., 2011; Nada et al., 2014).

On the contrary, barriers are represented by issues that may be solved or mitigated, even if they can limit the spreading of new technology. The majority of the papers do not treat the innovation barriers, while fourteen articles discuss them. The two most important barriers are given by the farmer's lack of technical knowledge about ICT and emerging technologies, and the lack of equipment, internet access, storage capacity and high-quality data, especially in developing countries. Bogomolov et al., 2021 for instance highlight the lack of qualified personnel and the lack of high-quality internet access as two of the main problems in the field of applied digital technologies in the Russian agricultural industry, which hinder productivity and efficiency improvement. Six papers deal with the high investment cost, and the related low perceived effectiveness, for instance, Wakjira et al., 2021 analyses a case of precision beekeeping in Indonesia and Ethiopia, highlighting the impossibility of using commercial systems of remote bee colony monitoring because local beekeepers cannot afford them. Finally, some sources treat the mismatch between farmers' practical needs and the available applications, the data control and data security problem, the lack of integration of the food supply chain, the large energy consumption of these innovations and the user psychological barriers to the implementation. Mohr & Kühl, 2021 focus on this last barrier with a study on German farmers. Their contribution underlines that the acceptance of AI depends essentially on two factors: the perceived behavioural control and the personal attitude of farmers. The following Table 1.11 reports the barriers on more detail.

Tab. 1.11 Explain the barriers.

Explain the barriers		37
	No	23
	Yes	14
	Farmers lack of technical knowledge about ICT and other emerging technologies	7
	Lack of equipment, internet access, storage capacity and high-quality data	7
	Lack of high-quality internet access on the agricultural lands	2
	Poor quality of data	2
	Limited access to modern practises equipment and infrastructures	1
	No research involvement in some small countries	1
	Limited stored capacity and scalability	1
	High investment costs and low perceived effectiveness	6
	Mismatch between applications and farmer practical needs	4
	Mismatch between farmers 'needs and software functionality	3

	Poor predictive ability	2
	Communication problems between system and user	1
	No information for specific types of events	1
	Lack of adaptive capacity to new changes	1
	Data control and data security	3
	Data security, privacy, and anonymity	3
	Data control and decentralization	2
	Lack of integration and complexity of the food supply chain	2
	Actually, no integrated system for connecting smart agriculture and food supply chain	2
	Complexity of the food supply chain as a consequence of heterogenous stakeholders	1
	Large energy consumption and unsustainability	2
	User psychological barriers to adoption	1
	AI acceptance is limited by the perceived difficulties of use and low usefulness	1
	Personal attitudes limit the AI adoption	1

Source: our elaboration (2023).

Concerning open issues, almost all the articles end without mentioning any kind of open issues. Only three sources leave the reader with a question mark. The first is related to the challenge of finding a way to feed the increasing global population in a sustainable way with the use of modern technologies which allows the rationale use of world resources to improve the state of the planet (Bogomolov et al., 2021). The second one concerns the need to find a practical way to organize the complex Agritech 4.0 food supply chain using integrated emerging technologies, such as IOT, cloud platforms and data-mining, through a holistic cyber-physical system ensuring transparency, traceability and consumer engagement (Eashwar & Chawla, 2021). Last but not least, the third contribution seeks to understand the potential and the usability of information across the food system (Wolfert et al., 2017). From the findings, we can understand as several articles discuss problems and challenges, but few sources explicitly finish with open issues for the readers, fostering new practices and research streams.

In accordance with the open issues node, only sixteen papers report research implications, ten of these concerning the need to extend and integrate the study with new types of data or focus on new related issues. The remaining sources advocate testing the proposed method, analysing deeply new aspects, and finally explaining the need to develop new solutions and new technologies. The following Table 1.12 reports the research implications on more detail.

Tab. 1.12 Research implications.

Research implications		37
	Yes	16
	Extend and integrate the research with new data or focus on new related problems	10
	Data collection from field operations could be used to support research and development in the agricultural sector	2
	Expanding the database with more farms of diverse characteristics	1
	Integrate the forecasting methods with analytics creating a common forum for farmers	1
	Create new systems for other types of crops	1
	Technical review of ML models applied in the agricultural domain	1
	Include study of the variations in base-period data and sensitivity analysis	1

	Integrate the model with other environmentally important factors and economic indicators	1
	Extend the research from a wider innovation perspective instead of a chain network perspectives	1
	Make deeper comparisons versus field measure	1
	Test the validity and accuracy of the proposed method	4
	Test the accuracy of the whole forecasting methodology from raw seasonal climate forecast to yield estimation	1
	Identification of the manager's decision-making phase and test the accuracy of the system	1
	Test the validation of the API pasture with data collected from livestock enterprises instead of platform data	1
	Test the actual system and automate the data using camera imagines for more specific values	1
	Focus on new aspects not yet deepened	3
	Focus on eliminate hunger on real terms focusing on smallholder farms	1
	Focus on bio-security issues of slurry management	1
	Focus on ethical aspects of big data	1
	Focus on governmental issues, the most inhibiting factors to big data implementation in agriculture	1
	Focus on develop new solutions and new technologies	3
	Focus on the research and test of technologies useful to the Agritech 4.0 supply chain from the field to the fork	1
	Research new highly productive solutions and create a common platform with a large database maintaining desired security levels	1

	Focus on standardization of new technology systems to benefit from large scale advancements	1
	Implement a fully automatic hybrid budget creating a fully integrated model of the basin	1

Source: our elaboration (2023).

Concerning the practical implications, a significant part of the sources (twenty-six out of thirty-seven), lead to some practical implications, especially for farmers. Indeed, as already explained, such a topic appears as a merge between theoretical insights and practical applications, and it welcomes practical user solutions. Half of these papers have the potential to help farmers in the decision-making process, while ten articles support everyday farming operations, increasing efficiency and effectiveness. No surprise AI is historically strictly connected to decision-making support with a strong increase in the last years as a consequence of the availability of new data sources and the decreasing cost of technological tools (Secinaro et al., 2021) . AI is able to make needed changes in the decision-making process supporting new ways to identify the key variables of the decision space, the interpretation of the process, the final result and the several alternatives with the possibility to replicate the transaction, reducing time and costs (Shrestha et al., 2019). Another significant practical implication concern the possibility of helping farmers in the planning process managing the implicit farm unpredictability. Finally, some sources provide farmers with new emerging and integrated technologies to develop and test. The following Table 1.13 report the results on more detail.

Tab. 1.13 Practical implications.

Practical implications		37
	Yes	26
	Support farmers in the decision-making process	13

	Enhance farmer decision-making by providing new ways of understanding current performance and identify potential areas of improvement	3
	Making easier the decision-making process for agrifood sector managers	3
	Construct a DSS for groundwater management with the active involvement of stakeholders and identify sustainable socio-economic and environmental strategies	2
	Various strategic decision variables and steps can be considered comprehensively by the agrifood managers	2
	Support farmers in the variety type decision considering seed enterprises as the main consumer	1
	Provide a platform for farmers to bring together spatiotemporal input data for modelling extensive livestock grazing systems and address different constrains	1
	Provide a DSS which help farmers to pursue both economic sustainability and ecologic safety under different seasonal climate variability	1
	Help farmers to obtain the optimal harvest date, especially in the case of young farmers	1
	Farmers learn that there is a great potential to improve yield and water productivity with better fertilizer regimes	1
	Support everyday farm operations increasing efficiency and effectiveness	10
	Help farmers improve everyday operations through recognition of problem situations and adaptive management of their resources learning from data	8
	Better productivity reducing costs	2

	Develop a technically robust, reliable, easy-to-use and easy-to-maintain service for beekeepers	1
	Provide farmers useful forecasts to manage the farm unpredictability by planning their activity	7
	Propose an algorithm to help agribusiness to predict the suitable crop from loaded input dataset	2
	Construct a DSS to predict the agricultural enterprise profit, other values and help farmers to successfully achieve their business goals	2
	Help farmers to plan their budgets and investments more effectively, calculate the risk and save resources	2
	Provide an operational framework for farmers to use seasonal forecasts in their crop management	1
	- *Help farmers to early prevention, early detection and early treatment effectively reducing agricultural production risk*	1
	Provide farmers new solutions with integrated technologies	3

Source: our elaboration (2023).

While coming to policy implications, notably, only nine papers report some policy implications, mainly represented by government implications. Four articles explain as governments should use the agricultural data from fields to improve policy-making decisions in this sector, learning from data permit them to realize better future forecasts, for instance through the smart irrigation system based on IOT and machine learning proposed by Kassanuk & PhasinamKassanuk. At the same time, four sources recommend governments to subscribe new investment plans to enhance the technological transition. For instance, Chiles et al., 2021 highlight as governments should invest on publicly accessible digital infrastructures easily a technological transition, simultaneously protecting platform workers 'rights and customer privacy. Two articles explain as they should contemporarily support the farmers in the technology knowledge acquisition. In this case, Sood et al., n.d. propose a solution to overcome the farmers' lack of technical knowledge already treated in the barriers through the creation of advisory units composed of experts, who must be empowered and enhanced in terms of capacity and resources. Finally, one article suggests that governments support social innovation by engaging the younger generations in the honey industry (Wakjira et al., 2021). The following Table 1.14 report the policy implications in more detail.

Tab. 1.14 Policy implications.

Policy implications		37
	No	28
	Yes	9
	Governments should use agricultural data to improve policy-making and decision-making learning from data	4
	Obtain data that can be used for policymaking in the field of agriculture and environment	1
	Predictive commodity prices help governments make decisions to prevent riots or famine	1
	Governments should utilize this IOT model to learn from data improving decision-making	1
	Governments should use this type of DSS with a GIS for landscape planning and water policy decisions	1
	Governments should subscribe new investments to enhance the technological transition	4
	Subside the new investments in the adoption of AI-solutions and provide high-quality internet connection on the agricultural land	3
	Governments should invest on publicly accessible digital infrastructure to facilitate the transition and protect platform workers' rights and consumer privacy	1

	Governments should create advisory units to support the farmers awareness about complex technological tasks.	2
	Governments should support the social innovation to engage younger generations to be more involved in the honey and bee industry	1

Source: our elaboration (2023).

1.3. Discussion

As already explain in the introduction, this study aims to examine and better understand the role of AI and related technologies in the Agritech sector highlighting advantages and disadvantages but especially focusing on the possibility of AI to create new business models.

Our results underlined a high number of collaborations and the presence of papers authored by practitioners. Such a finding suggests that this topic represents an advanced and high-technical field where theory is strictly connected to practical applications. Innovation happens first in practice and can lead then to academic works and reasoning. Therefore, the practitioners' role in the field is extremely important. Academics are so invited to partner with managers and private companies to study the advancements and innovations in the field, share the best practices and business cases, and suggest methodologies to assess the technology, measure, and report its impacts, suggesting practical, research, and policy implications.

The unusual number of conference proceedings extracted from Scopus and included in our analysed sample can be connected with the previous point concerning the role of practitioners. Indeed, when high-technological fields are under the academic lens, scholars tend to present an early-stage draft of their works at conferences, getting feedback from their fellows before submitting their articles for peer review. In the case of AI applied to agriculture, the implementation of new technologies and new agricultural innovations are initially presented during conferences and only after are discussed in the academic literature.

Another interesting result comes from the locations where the studies were conducted. The topic is widely diffused around the world, with a concentration in Asia, which is actually the hub of global innovation. Asian countries are implementing several policies to support innovation, start-ups, and the creation of business incubators, as explained by different key representatives during the Consumer Electronics Show in Las Vegas in January 2023, a clear instance is China with over 480 participating companies, which actually constitute a vast market with rich application scenarios for new technologies (GT Staff Reporters, 2023). From our yet limited sample, Europe is actually even behind the USA and South America. The European Union should, therefore, promote innovation with projects and dedicated funds, especially for small and medium farmers which constitute the majority of the global agricultural entrepreneurs. Of 570 million of farms worldwide, 75% are family enterprises and 12% are micro-enterprises which cultivate less than 2 hectares of land (Lowder et al., 2016). Furthermore, while Africa appears in our sample with just a few contributions, it may represent an exciting outlet for technology providers, given its significant presence of arable land and the actual low level of technological advancement. While more barriers may be present than elsewhere (especially concerning the lack of infostructure and the financial investments needed), Africa stands as a continent whose development may largely benefit from AI.

The research methods adopted underline how case studies play a vital role in the literature. Interesting enough, most of these cases do not "tell" success stories of companies or farmers. Still, they assess and discuss new innovations and their practical applications. That is also why most cases do not refer to any specific geographical location, but they just refer to new applications that may be employed everywhere. Even if such a development may sound "natural" considering the field and the speed of change, the scientific community should share more success stories, even comparing multiple cases, highlighting advantages and disadvantages of some solutions. In addition, another key issue may be represented by the rate of acceptance of these new applications in practice. Therefore, quantitative research methods like surveys and questionnaires should be tested to farmers and especially agricultural operators, which directly use the technological application during their everyday operations. Again, researchers should target small and medium farmers, who represent the majority of agricultural enterprises in several continents, but who often have little capital to invest, and a lower level of technological knowledge. The latter is indeed reported in the barriers as one of the most significant hurdles to the digital transaction. For this reason, trade associations and agricultural consortia may organize open recurring conferences to diffuse and disseminate the opportunities brought forth by AI and industry 4.0 to all the operators in this field. Examples of such policies may be represented by initiatives such as the European Innovation Partnership 'agricultural productivity and sustainability' and the multi-actor approach, a key component of several Horizon 2020 projects, which permit to connect people, sharing knowledge and tackling challenges. (Koutsouris & Zarokosta, 2020).

Regarding the types of technology mentioned in the selected works, an interesting aspect should be discussed. Although the research key used in Scopus specifically mentioned the words "Artificial Intelligence," twelve different types of technologies are reported. This fact may be explained as AI is only a part of a greater system of industry 4.0 digital paradigms used as methods to develop analysis and prediction with further disciplines such as data science, electronic engineering, and so on. For this reason, AI is a technology that may be fully integrated with other digital paradigms such as smart manufacturing, autonomous and collaborative robots, augmented and virtual reality, industrial internet of things (IoT), cloud computing, big data analytics and cybersecurity, permitting to reach economies of scale with high levels of personalization (Bagnoli et al., 2022). The industry 4.0 model is based on the following actions: sense, connect and think. The former is the essential activity of collecting data from the external environment through sensors incorporated in the products, while the second is the activity of transmitting the data to the users. About these two processes, IoT plays an essential role because this technology connect devices of different nature communicating each other and especially with a centralized unit of control. For this reason, relying on a high-quality internet connection is fundamental. This is also reported in our analysis as one of the major technological barriers, which must be provided by governments as an action to promote the agricultural technological transition. The higher the number of IOT devices, the better the outcome of the third action will be. In this last process, AI comes into play because it represents a useful input in decision-making, together with DSS and data-analytics, which do not substitute human judgment but rather support the decision-makers in categorizing data and creating future forecasts. (Badan et al., 2017; Mattiello, 2019). Also in the agricultural sector, we notice this complementarity among technologies which explains our results. Notably, particularly significant seems the relationship between AI and IoT, merged by H. Li et al., 2022 in the new term "AIOT."

As already reported in our results, a relevant number of practical implications are related to decision-making support provided by these new technological implementations. At this point, the farmer's capacity to use these innovations in the right way looks fundamental. About the practical application in agriculture, we note precision farming as a new method to increase efficiency and reduce losses. Precision agriculture could be defined as a new method of smart agriculture which permits connecting resources with needs, growing, in this way, efficiency and productivity while also reducing the environmental impact and the unpredictability of the farm return (Boursianis et al., 2022). Other interesting applications are those related to traceability, which tries to replace the increasing customer demand for transparency and food safety after the scandals of the last years such as tainted milk in China, mad cow disease in Britain, E. coli infected cucumber in Germany and peanut butter infected with bacteria in the U.S (Treiblmaier & Garaus, 2022). In this context, the Blockchain covers a vital role proving itself as a technology able to increase consumer trust and accountability preventing food fraud, tracking any food through all stages of production, processing, and distribution, with a new model of digital supply chains (Dal Mas et al., 2023). This type of innovation could be excellent to defend and ensure the authenticity of some typical products, such as those labelled with the European label of protected designation of origin (PDO) or protected geographical indication (PGI), which provide added value to consumers.

Even if the words "Business Model" were specifically included in our search, the majority of the source analysed do not speak about any specific business model. Even the papers that somehow mention the matter do not clearly explain the business model name. While coding the articles, the researchers had to interpret them case by case. Interestingly enough, there is a lack of business model definition in all these papers. Still, new technologies are supposed to be the triggers of new business models with a technology-driven innovation, they usually permit to change the competitive environment through incumbents' upheaval, caused by their inability to respond effectively to external environmental changes (Habtay, 2012). Micheal Nilles -chief digital information officer of Henkel- define digital transformation as the Holy Grail, "not easy to find, not easy to capture but able to dramatically improve the customer experience" creating new disruptive business models (Bagnoli et al., 2022; Hinterhuber, 2022). Even in our limited sample, the search key was precise, but the results are, in this matter, discouraging probably given by the fact that business model innovation require companies and entrepreneurs willing to disrupt their traditional business developing digital and competitive strategies to drive innovation and business growth (Bagnoli et al., 2022). This opens up exciting research avenues in mapping and defining new business models in the agricultural field, their unique features, the opportunities they may bring, the outcomes, the chance to involve different stakeholders. Researchers may borrow some sound results scouted in other fields; a good instance is Airbnb, using digitalization and a marketplace platform model it was able to completely change the hotel industry offering a connection between people which have a space to spare with those who are looking for a place to stay (Bashir & Verma, 2016). Another instance could be Netflix which providing a digital and on-demand way to watch films and series destroyed the movie rental industry through a new subscription-based business model (Anindita, n.d.).

A possibility to lead a new business model treated in the academic literature is the platform business model in the agricultural sector. An instance of this new business model could be Apollo Agriculture, a Kenyan-Dutch agro-tech platform that aims to support the smallholders to obtain agricultural inputs through digital voucher used to pay agro-suppliers. In this way the small farmers pay only the 10% at the beginning of the agricultural season, paying the rest after the harvest. The platform connects smallholders with insurance companies to reduce the crop risk and control the line of credit (Tuijl & Zambrano, 2022).

All in all, the scientific community should increase the research in this field, which represents historically the base of the global economic system developing new business models and trying to find a way to solve the actual open issues. The need to feed the increasing global population is surely the most important challenge of the next years, taking into consideration the sustainability issues, as we can also notice in the open issues results. According to United Nations World Population Prospect 2022 the global population will be 8.5 billion in 2030, 9.7 billion in 2050, and it will reach 10.4 billion in 2100 as a consequence of declining levels of mortality (Photo & Debebe, n.d.). For these specific reasons food security is one of the United Nations Sustainable Development Goals on which all the governments of the world should seriously work together to find a global innovative solutions (Spanaki et al., 2022). Digitalization, technological development, and biotechnology in the agricultural field are probably the only available solutions to feed this increasing population, taking into consideration the decrease of productivity in the last years as a consequence of climate change and desertification (Bogomolov et al., 2021). For this reason, in the last years, several projects started which have actually low people acceptance but surely will become popular in the future if there are no alternatives, an instance is cultured meat which permit to produce of meat culturing animal cells in vitro utilizing 7-45% less energy, 99% less land, 96% less water and emitting 78-96% fewer greenhouse gas emission (Choudhury et al., n.d.).

Only two articles give a clear definition of AI highlighting another time the high level of practicality in this field. Several sub-branches of AI has been incorporated into the AI technology, especially machine learning, artificial neural network (ANN), support vector machine (SVM), convolutional neural network (CNN), adaptive neuro-fuzzy inference system (ANFIS) and finally deep learning. These are specific fields within the AI world which permit to achieve different objectives and solve several problems. These could be used for several reasons, for instance in the case of Deng et al., 2011, the ANN, SVM and ANFIS have been used to create soil water simulations and predictive analysis in the red soil region of China, with the aim to optimize the water management and increase water efficiency, starting from daily soil water time series and meteorological data.

Although we did not focus our research on the sustainability issue in agriculture, the findings show that the two topics are extremely related. We can say that sustainability is an integral part of agriculture, essentially for two reasons. The first is given by the fact that farmers should take into consideration the environmental impact of their activity. For instance, Vizzari & Modica, 2013 discuss about the pollution created by swine swage in the Lake Trasimeno, in the Umbria region in Italy. This impact could gradually reduce the productivity and quality of the crops. The second factor is caused by the influence of the environmental variables on the seasonal outcome, which determines the farm profit. This is intrinsically at the core of farm management but now, with digital technology support, it is possible to manage farm unpredictability sustainably. For instance, Ahmed et al., 2022 highlight as with the usage of available data sets and the realization of what-if scenarios is possible to achieve sustainable development in the long-run through effective mitigation strategies. A new innovative paradigm is given by vertical farming, a new way of production which permit to control all the agricultural variables using the so-called Controlled Environmental Agriculture together with the nature co-design, in this way is possible to increase resilience and circularity through hydroponic cultivation and advanced led lighting systems (van Gerrewey et al., 2022). Actually, this new paradigm represents a change in the game rules and, although it is actually very expensive (especially for the construction cost which represent the initial investment) and difficult to create economies of scale, the policymakers should invest through specified funds to find solutions able to both create wealth and preserve the environment where we live. From the theory, we know that technology, especially AI, is able to create new sustainable business models improving technical-scientific quality of the production system, for this reason we should focus on the realization of application which provide both profit and sustainability (di Vaio et al., 2020). An example could be a weed control machine developed by Blue River Technology, a start-up recently acquired by John-Deere, which use AI to distinguish crops from weeds spraying herbicides where weed is present, in this way is possible to reduce the chemical usage with both environmental and economic benefits (Deng et al., 2011; Misra et al., 2022). Only few articles explain about disadvantages, probably because, as already discussed, a great number of sources are theoretical presentations, and they prefer to highlight advantages with respect to penalties. However, the academic community should practically start to compare the different technological innovations with an external point of view, making some judgements based on opportunity and threats, expected revenues and costs of implementation. The barriers instead are particularly relevant, as they present the new challenges to overcome, the starting point for research, practical and policy implications. We have already discussed about some underlined barriers such as lack of farmers ICT knowledge and new innovation acceptance, but we need to notice as a great number of sources cite these barriers without giving or proposing a solution. Findings explain how these barriers in some cases are agricultural specific, such as in the case of the complexity and lack of integration of the food supply chain, but the majority are general barriers to the implementation which are common to all other sectors. As already suggested, the Agritech field could borrow or adapt solutions created and already implemented for other sectors solving a great number of problems. For this reason, it looks fundamental to engage the collaboration between agricultural key participants and actors involved in other sectors, which together could solve the general barriers to the implementation and finding common solutions. An instance of a solution from other sectors is the agrovoltaic system which is a photovoltaic panel system adapted for agricultural needs. This is extremely interesting because it is a system that uses arable land for crops and energy from solar panels, contemporarily harvesting rainwater. In this way it provides a new power source to solve the large energy consumption barrier of the new technology and offers a way to deposit rainwater from the same piece of land that used for farming (Sreekar et al., 2022). Governments should invest heavily in the research of new general solutions and especially in the adaptation of existing systems.

1.4. Structured literature review conclusion

Our contribution underlined the importance of AI in disrupting the agricultural sector by offering sound solutions to farmers and entrepreneurs in the field to support their decision-making process and increase the farm's profitability. Still, literature and practice are in progress, with more solutions and applications being developed and tested and more opportunities to disrupt business models, even fostering sustainability practices. More academic engagement with professionals should be carried out to suggest and spread new managerial and organizational procedures.

Several new research avenues have, therefore, been suggested: from the employment of quantitative research methodologies to a deeper collaboration with practitioners, from spreading best practices and lessons learned to comparative studies among different contexts and countries. New themes include the degree of technology acceptance up to the educational ways for farmers.

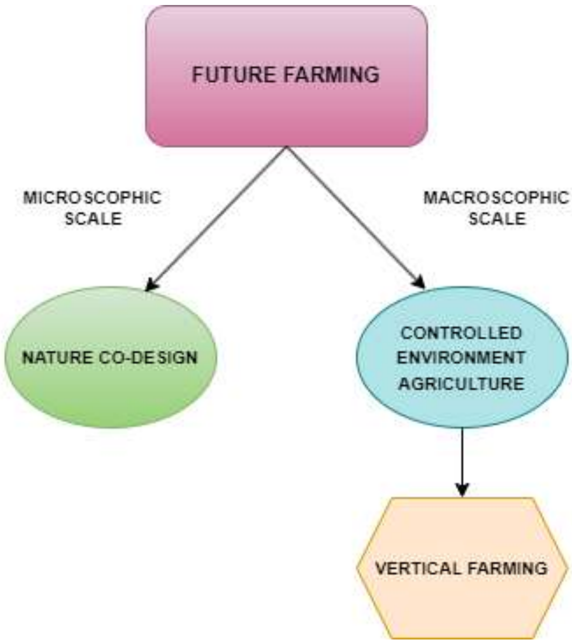
As with all studies, ours have limitations. Even if the methodology can be considered rigorous and replicable, the sample of analysed sources is limited, and the coding process may leave room for subjectivity. Moreover, the speed of technology development and the quantity of new academic pieces published every month may impact the validity of our results. Such limitations may lead to further research opportunities to frame the phenomenon and its fascinating yet helpful outcomes, also scouting the so-called grey literature.

Chapter 2: the ZERO case

2.1 Chapter introduction: Future Farming, Nature Co-Design and Controlled Environment Agriculture

Vertical farming represents a branch of one of the two emerging trends of Future farming, an innovative alternative to the traditional methods of cultivation which could be defined as "the new industrial revolution inspired by nature" (Nature Co-Design: A Revolution in the Making, 2021). These are Nature Co-design and Controlled Environment Agriculture, the former is on the microscopic scale and is based on the match between biology, chemistry, and material science. For the first time in the history, there is the possibility to use the nature as an atomic-level manufacturing platform passing from a purely extractive-linear economic model to a circular regenerative model. The second trend, which included vertical farming, is on the macroscopic scale and propose a method of cultivation in a controlled environment maximizing harvest yields, minimizing the consumption of natural resources, and completely eliminating the use of pesticides (Ragaveena et al., 2021). In the following Figure 2.1 a graphical representation of the future farming trends.

Fig. 2.1 Future Farming trends.



Source: our elaboration (2023).

2.1.1 Vertical farming method

Vertical farming is defined as "the process of growing crops in vertically layered stacks, incorporating controlled-environment precision-agriculture technologies (including LEDs, Internet of Things, hydroponics and data analytics) to maximise growing yields while minimising inputs (eg water, fertiliser and pesticides)" (Wilson & Chevalier, 2020). Vertical farming has the potential to solve the main agricultural problems by deseasonalising agricultural products and making them available at any time of the year to consumer demand. Another important factor to take into consideration is the opportunity to place the crops in urban contexts making the products available at km0. In this way, there are both transportation cost savings and food-miles reductions. These advantages have the potential to positively disrupt the actual fresh produce supply chain bringing benefits to both consumers and farmers. Vertical farming was minted in 1915 by the American geologist Gilbert Ellis Bailey while the practical invention is to be attributed to Professor Dickson Despommier in 2008 (Al-Kodmany, 2018). Today this method of cultivation is not only environmentally sustainable and diffused around the world but also economically and financially sustainable. (Thorat & Deshmukh, 2020). Traditional agriculture yield growth has stabilised below the growth rate needed to meet the expected increase in demand by 2050, when the global population is expected to reach 9.7 billion with a 25% increase from today (Vertical Farming - Barclays - Mar 2020, 2020). In this situation, vertical farming represents a fundamental solution to take into consideration in the future farming context. Several factors today push the demand for vertical farming practices as explained in the following Figure 2.2 (Wilson & Chevalier, 2020).

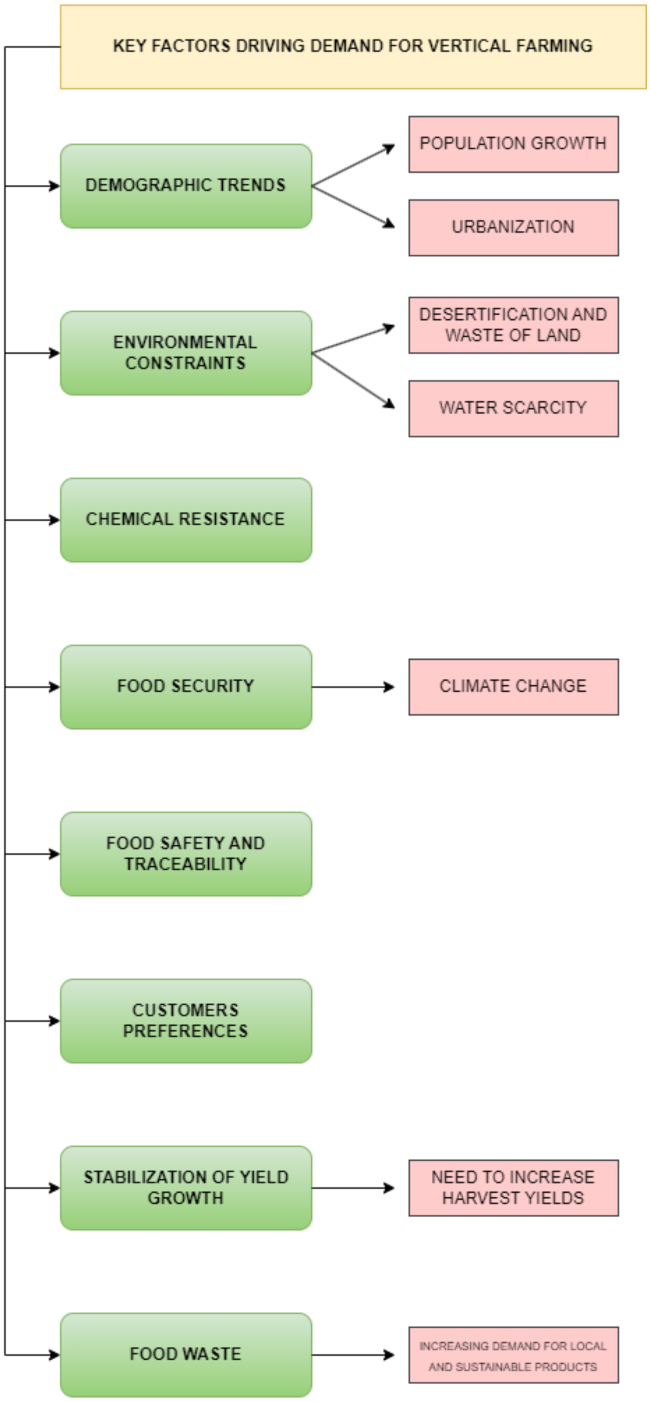
There are essentially 3 vertical farming growing technologies:

1. Hydroponics: grow plants using mineral nutrient solutions, in water, without soil. Easy method to set up and maintain but needs prevention of algae & fungal in water.

2. Aeroponics: grow plants in indoor aeroponics factories without soil with the aid of artificial lighting. Less water needed and faster plant growth than other types are the advantages. Greater maintenance effort are needed, and set-up is more complicated than other types.

3. Aquaponics: grow plants in indoor setting using nutrient-rich natural fertilizer resulting from raising fish. Water recycled & healthy nutrients provided through fish are positive factors but water & space requirements for fish are higher than other types (Kurth et al., 2020).

Fig. 2.2 Key factors driving demand for vertical farming.



Source: Wilson & Chevalier (2020).

2.1.2 Vertical farming market overview

The vertical farming market is growing. According to Global CEA Census Report WayBeyond, 2021, 81% of vertical farms plan to increase the vertical farming production area in the next years. The global vertical farming crops market was valued at $212.4 million in 2019, and is forecasted to reach $1,384.6 million by 2027, with a CAGR of 26.2% from 2021 to 2027. North America was the highest market share accounting for $74.6 million of revenues in 2019, and is estimated to reach $473.5 million by 2027, with a CAGR of 25.8%. Asia-Pacific is estimated to reach $416.8 million by 2027 at a significant CAGR of 27.0%. North America and Asia-Pacific collectively accounted for around 63.8% share in 2019, with the former constituting around 35.1% share. Asia-Pacific and Europe are expected to witness considerable CAGRs of 27.0% and 26.5%, respectively, during the 2021-2027 period. (Thorat & Deshmukh, 2020).

In February 2020, the Barclays 2030 Thematic Roadmap has been identified the 150 trends that analysts believe will dominate the investors' discussions over the next decade. Vertical farming has been identified as one of these key trends because it could ensure a sustainable and fresh food supply at a local level. Moreover, the vertical farming report forecasts a 50 billion of market size opportunity in 2030 based on FAO data on gross production, hypothetical ideal products for this method of cultivation and the addressable market which could shift from conventional to vertical farming (Vertical Farming - Barclays - Mar 2020, 2020).

The vertical farming market actually is mainly braked by two factors which represent the hurdles to overcome:

1. High initial cost investment (Capex), high infrastructure and operating costs, requirement for a skilled workforce, especially for plants that require pollination (Opex). One of the higher operating costs is represented by the cost of electricity because compared to outdoor farming, greenhouse growers used 15-20x as much energy, on average, and vertical farms used a little over 100x as much energy (Global CEA Census Report WayBeyond, 2021).
2. Limited varieties of crops compatible for cultivation because current vertical farms opt for quick-harvest models that focus on high-value, rapid-growing, small-footprint, and quick-turnover crops (Thorat & Deshmukh, 2020).

2.2 Case study: ZERO

2.2.1 Company Presentation

ZERO is an Italian company with high technological impact located in Pordenone, Friuli Venezia Giulia, and led by Daniele Modesto, CEO of the company.

ZERO was born in 2015, and its name is given by the idea to restart from ZERO, fully rethinking the vertical farming sector, democratising access to vertical farms products reducing their price. The vertical farming method of cultivation is strongly limited around the world because, although it sustainably produces high-quality products, actually is not financially sustainable. The main problem is given by the extremely high cost of the vertical farm system, which on an average amount of 2000 €/m^2 and for this reason is not financially scalable. For this reason, the ZERO main goal was to realize a scalable vertical farming system through a modular architecture adaptable to several dimensions. This goal was achieved in 2018 when ZERO realized a hardware-software technology called "ZERO Modular Architecture" with 100% of personal intellectual property. This system entered the national and international market in 2021 after 6 years of research and development on which the company could totally internally produce each vertical farm component minimizing time and costs. Moreover, the company realized an AI system (called ROOT, the virtual agronomist) which, together with smart LED, increase of 400% the crop yield with respect to a traditional greenhouse and 200% with respect to traditional vertical farms reducing 25% of labour costs. This aero-floating system reduces of 95% the water consumption without necessity of pesticides, moreover, concerning a traditional vertical farm reduces of 50% the power consumption.

From a sustainability point of view, the patented aeroponic cultivation system uses plastic sheets, which are totally washed and sterilized at the end of the production cycle, instead of peat as others vertical farming systems. Peat in fact is not completely environmentally sustainable because there is the need to dispose of it when it is no longer usable, increasing costs and environmental impact. In the ZERO cultivation system the plants are sprayed with water and nutrients recovering everything that is not absorbed by plants, the only waste product is actually given by the roots. Moreover, this method of cultivation allows plants to grow in an environment free from pathogens present in the natural environment with no needs of pesticides and washes, for this reason the ZERO Farm products have longer storage times.

The future goal of ZERO is to increase the cultivated area realizing economies of scale which permit to reduce the vertical farm investments to the point of equalling the traditional greenhouses installation costs. The following Table 2.1 reports a comparison between Greenhouse's cultivation, vertical farming cultivation and ZERO method.

Tab 2.1 ZERO comparison with modern greenhouse and generic vertical farm.

	Modern greenhouses	Generic vertical farms	ZERO
Investment costs	200-500€/m^2	±2000€/m^2	≤2000€/m^2
Productivity	10kg/csm	20 kg/csm	40 kg/csm
Structural environmental impact	High	Low	Low
Method of cultivation	Land, peat	Peat, Hydroponic, aeroponic, substrate of bacteria, fungi, algae	Aeroponic patented method
Product quality	Moderate	High	High
Use of pesticides	Sometimes	Never	Never
Crop provisions	Difficult	±100% reliability	±100% reliability
Cultivation environment	Not fully controlled	Fully controlled and sterilized, free from pathogens	Fully controlled and sterilized, free from pathogens
Product characteristics	Conventional or organic	Chemical free with no need to wash	Chemical free with no need to wash
Price point	Conventional or organic	More than organic	Organic comparable

Source: Global CEA Census Report WayBeyond (2021).

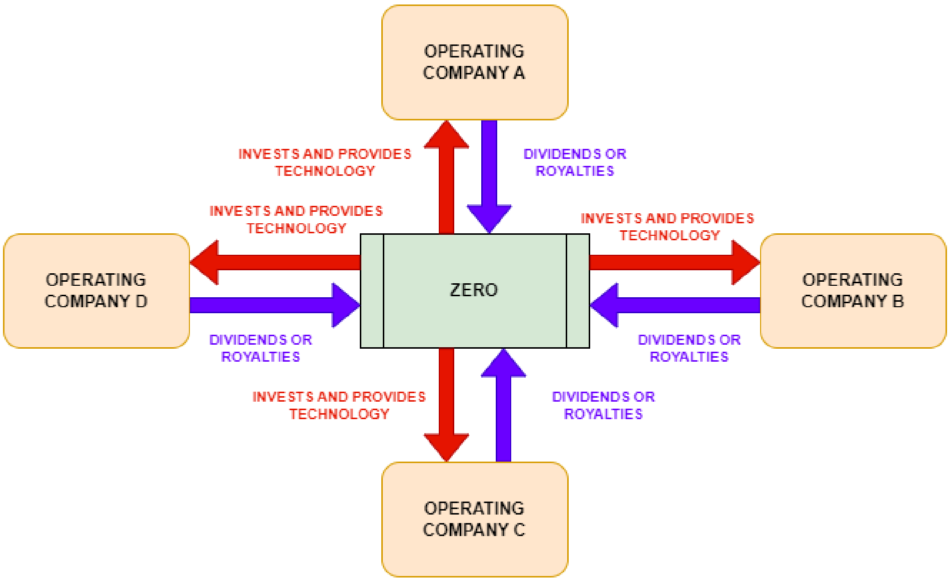
2.2.2 ZERO Business Model

ZERO is a technological company defined as a grower with proprietary technology, which decided, as explained by Daniele Modesto, CEO of the company, not to sell its technology but instead to invest in it. For this reason, ZERO divided its business into two parts which work as a holding:

1. ZERO: it represents the technology platform which is not a profit centre but only a cost centre. It owns the ZERO Modular Architecture, and it will continue to invest in the next years with a long-term project, for this reason the ZERO goal is to cover the investment costs by focusing on the revaluation of the intellectual property. ZERO invests in several operating company buying their shares and entering their capital becoming a shareholder, often in a controlling position. Moreover, it provides its technology and continuously manages remote operations using the software present in the plants. Every year ZERO will receive dividends or royalties from its operating companies, we can say that ZERO represents the technology platform on which all the projects are based.

2. Operating companies: they are vertical farms, and they are the profit centres selling the final product, for example salad, tomato, etc. Each operating company represents a project on which ZERO decided to invest and provides positive returns. Each project must be profitable from the first year otherwise ZERO will not find partners willing to collaborate. ZERO has several projects with different operating companies, for instance it has partnered with Barilla, a famous Italian company of the food sector, for the cultivation of basil used in the Pesto production. In the following Figure 2.3 there is a graphic representation of ZERO business model.

Fig. 2.3 ZERO business Model.



Source: our elaboration (2023).

2.2.3 Suppliers

ZERO suppliers work with an integrated supply chain, they are mainly engineering companies which provide aluminium, electrical components, and everything necessary for the construction of the place of cultivation. Other suppliers provide seeds and consumables for the farm's cultivations.

2.2.4 Resources

Tangible resources are mainly real estate land and company structures, machineries, and administrative offices. Intangible assets are represented by human and intellectual capital such as several specialized figures mainly in the engineering, molecular biology, finance, and agronomy fields, with transversal skills. Software and AI systems for the agronomic experimentation represent the technological capital. ZERO owns a registered brand called "Orto verticale" and several patents including those relating to the technical aspects of plant operation such as air distribution system, cultivation supports, the plant modularity and the water nutrient distribution and recovery system.

2.2.5 Internal processes

Internally ZERO produces all the technologies needed to the vertical farm cultivation by being a grower and technology owner. This decision called “insourcing” permits to generate economies of scale and together protect the company know-how.

Moreover, ZERO internally manages the purchases of raw materials and goods, the realization of new projects, management control and administration, IT, innovation, strategy, and quality control.

2.2.6 External processes

ZERO communication channels are mainly represented by its web site and social network profiles (for instance Facebook, Instagram, and LinkedIn official pages) through which the customers can always be periodically updated about new company activities.

Distribution channels are actually wholesale with the majority of the farm’s final product sold to the Eurospesa supermarkets of Dado Group Spa. Moreover, as already said in the last periods ZERO partnered with Barilla and probably in the next future there will be the possibility for new collaborations.

2.2.7 Products and services

The cultivated products are actually Monovariety and mixed salads, herbs and 15 microgreens variety. The company is developing strawberries, wild strawberries, and cherry tomatoes cultivations to expand the production capacity in the next periods. The main goal is to exceed three thousand tons per year of products. ZERO products have a longer shelf life with respect to conventional products because they are packaged immediately after harvesting without need of stressful industrial washes.

2.2.8 Customers

Customers are represented by people which periodically consume vegetables and give high importance to the food quality and origin without considering only economic factors. They are driven by sustainability purposes and by products which respect the natural environment minimizing the resources and maximizing the crop yields. Actually, there are three kinds of customers: supermarkets, food companies and Horeca.

2.2.9 Society

ZERO is an innovative start-up which pays particular attention to the issue of environmental sustainability aiming to realize several of the ONU 2030 Sustainable development goals. The company focuses to provide an offer to the potential demand for good and healthy products at an affordable price.

2.2.10 Value proposition

ZERO value proposition consists in the creation of a good which permit to buy an innovative product that go beyond the conception of traditional agriculture with a more technological point of view. Sustainability with accessible product price is the two points on which the company is extremely focused with its slogan “it’s time to jump”.

ZERO main activity is to sell its products and services in the national and, in the next periods, in the international market increasing sales volumes and customers. In this way the company will increase its public imagine and it will continue to develop new technologies, moreover it will continue to become always closer to the final customers obtaining the possibility to better understand their needs and preferences.

In the following Figure 2.4 a word cloud realized using crmodel (https://www.crmodel.net) which represents ZERO value proposition based on its web site description (https://www.zerofarms.it/).

Fig. 2.4 ZERO value proposition word cloud.

Source: our elaboration (2023).

2.2.11 Cost and revenue model

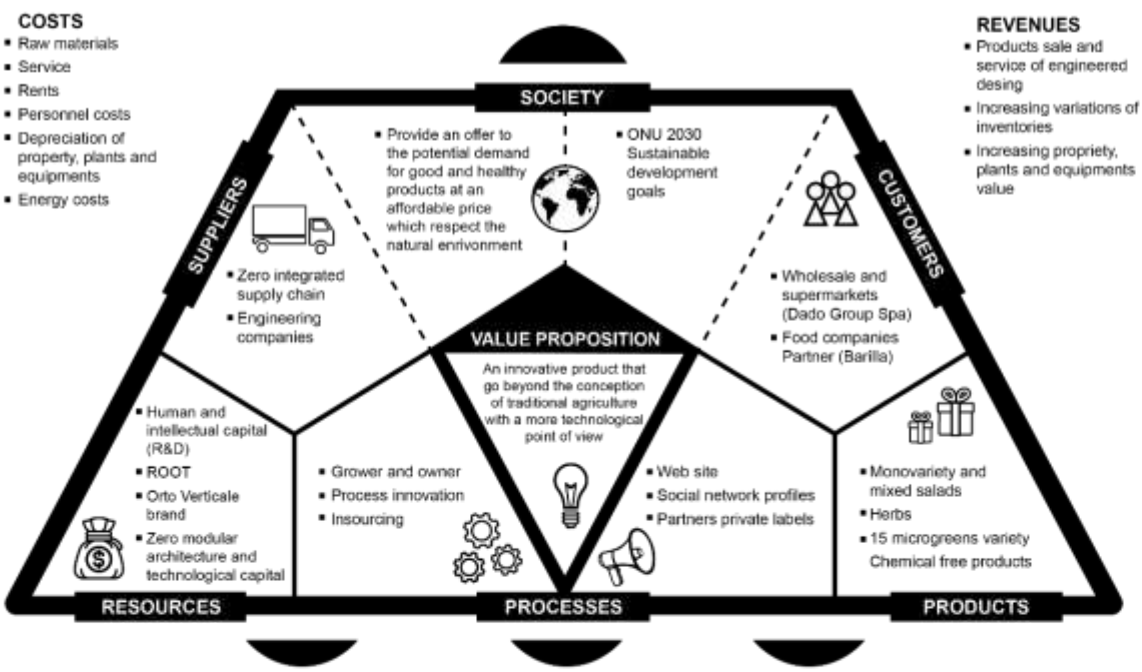
The main costs are correlated with operating activities such as raw materials cost, service cost, rents, personnel costs and depreciation of property, plants and equipment. One of the higher impact is given by the energy costs.

Revenues essentially are attributable to three macro-categories:

1. Revenues from the products sale and service provision of engineered design.
2. Revenues from increasing variations of inventories registered at full industrial cost.
3. Revenues from increasing property, plants and equipments value for internal work using the criterion of full cost of production.

In the following Figure 2.5 the ZERO business model canvas.

Fig. 2.5 ZERO Business Model Canvas.



Source: our collaboration (2023).

2.2.12 Company strategy

ZERO strategy is based on the introduction of new innovative solutions in the agricultural sector which increase volumes of production without negatively impacting environmental sustainability. The competitive strategy is a cost leadership on a wide

target because the company want to obtain the highest quality production and productivity reducing costs through economies of scale. This permit to sell its products with a price equal to the organic products and lower than the same goods manufactured by competing vertical farms. In the following Figure 2.6 a graphical representation of the relationship between price and quality, safety, and environmental sustainability with ZERO positioning.

Fig. 2.6 ZERO price positioning.

Source: our collaboration (2023).

2.2.13 Company vision

The company's vision is to maximize the cultivated area reaching the greenhouses hectares of cultivation, considering that vertical farm agriculture is a kind of controlled environmental agriculture which could be realized everywhere with whatever climate conditions. This location-free characteristic permit democratise the food access, moreover the controlled environment agriculture gives the possibility to predict harvests making reliable business plans. In this way there is a reduction of the gap between the primary and secondary sector through a new concept of industrialized agriculture.

The company owns a strong competitive position because ZERO technology is constantly under development with continuous investments in the search for a sustainable ecosystem that responds more effectively to customer needs. The vertical farm's competitors are not able to offer the same products at the same price while organic competitors are discouraged by high barriers to entry.

Finally, ZERO strategy is based on knowledge which permit to own an innovative competitive knowledge represented by the ZERO modular architecture system. This model has several possibilities of use which are not limited to production of food, as already stated by Daniele Modesto, but could be extended to the cultivation of medicinal herbs for the production of natural medicines, fungi, and melds for the creation of vegetable leather.

We can say that the ZERO generic strategy is conservative knowledge management, for this reason the company did not decide to sell its technology but continuously invest on it.

2.2.14 Company future strategy

In the next periods ZERO could apply essentially two strategies to achieve its original scope:

1. The first strategy is to decide on which business to focus and enter creating its own brand. This increase both profitability and risk because needs huge investments in communication to increase its visibility towards consumers with no certainty of being able to sell the product. Products with ZERO label are in a testing phase in which they are sold in the Eurospesa supermarkets.

2. The second strategy is to continue to provide production capacity to a private label which uses its brand and implements its personal communication strategy. In this way there is the certainty of saturation of production capacity but is not easy to find a potential retailer able to sell the product with a super-premium price taking into consideration that private label product are usually sold with lower prices. Following this strategy ZERO maintains distinctive resources ownership focusing only on the capital appreciation of its technology, for this reason there is a high threat that sooner or later their technology will be copied.

A third strategy could be to sell ZERO technology which has been eliminated because not admissible and against society's business model, as already explained by the CEO of the company.

2.2.15 The Future Farming District

In 2021 the company announced the project called "Future Farming District" which includes the creation of one of the largest vertical farms in the world in Capriolo, a town located in the Brescia province (Italy). This project was born from the collaboration between ZERO and Iseo Idro, an investment company specializing in the acquisition and management of renewable energy production plants founded by a group of South Tyrolean entrepreneurs. It's a total initial investment of over 60 million euros for the first phase and an additional 40 million for the completion of the second phase scheduled for completion by 2025. In the industrial complex will be built six standardized blocks of 9000 m^2 and 10 600 Z_m^2 each. The area chosen to host the district is that of the Oglio Park, a strategic position that allows reaching all of northern Italy, Switzerland, the south of Germany and Austria with short-range logistics. Moreover, the proximity to the system of hydroelectric plants located on the Oglio river, the largest is within the industrial complex, permits obtain clean energy production with lower costs. This is an original and innovative formula which together combines industrial regeneration and prefabricated buildings with clean energy production, research and development activities and education with the scope to educate the next generation of customers. Italy is the worst possible place to start a project like this given the Italian gastronomic tradition and Italian bureaucracy, exactly for this reason it is the perfect place where to test this format which ZERO aimed to replicate on others Italian locations and abroad. The Future Farming District will be dedicated to a small branded production and a broader partnership strategy with national Retailers aimed at launching private label programs following a mixed strategy. This synergy with Retailers will allow the company to focus on operating the technology, in a virtuous circle that creates value for the project, for the territory, for the distribution and for the final consumer. The production started in 2022 which after the phase one conclusion will reach 1300 tons per year with a cultivation area of 31 000 m^2. This will be doubled after the conclusion of the second phase with the introduction of high-quality strawberries.

2.3 Methodology

The case study applies a qualitative methodology based on a semi-structured interview on a single case study to evaluate the AI impact in the agricultural sector and its potential to create new business models. Massaro et al., (2019, pag.275) defined qualitative method as a research method which "allow researchers to discover to reveal and understand relationships between variables even within complex processes, and to illustrate the influence of the social context".

Several semi-structured interviews were carried out both via online calls and in presence to generate results for the study, as reported in the following Table 2.2.

Tab. 2.2 Data collection process.

Methodology	Object
Semi-structured Interview	CEO of ZERO
Qualitative and Content Analysis	Two company consultants
	ZERO 's official website
	ZERO's social network profile

Source: our elaboration (2023).

The following Table 2.3 illustrates the fifteen semi-structured interview questions. For each of the questions, references from the literature are provided, and these are then combined with a potential response which the participant could have provided. Three people were interviewed, ranging from the company consultants to the company CEO. Each of the interviews lasted from 15 to 30 min. The interviews took place remotely via telephone and video call connections. All of them were recorded and transcribed, and their main findings were coded.

Tab. 2.3 Research Protocol and semi-structured interview questions.

Interview question	**Potential/Expected response**	**Reference(s)**
1. What is the AI role in your company? Which agricultural problems could be solved with AI? Explain an advantage and a disadvantage of AI implementations within your company?	-ROOT -Reduce personnel costs -increase efficiency reducing human mistakes	(Panpatte & Ganeshkumar, 2021)
2. Do you think AI has the potential to disrupt the actual and create new business models in agriculture?		
3. If yes, what are in your opinion new possible business models in the agricultural sector? Are they technology-driven or market-driven?		(Habtay, 2012)
4. Do you think that AI improves farm sustainability? On which way?		(Sood et al., n.d.)
5. Do you think that farmers have the right level of ICT knowledge to exploit efficiently AI? If not, what could be some initiatives to solve this problem?		(Bogomolov et al., 2021; Panpatte & Ganeshkumar, 2021)
6. What are the main barriers which hinder the AI implementation in the agricultural sector? Why is		(Mohr & Kühl, 2021)

there backwardness concerning other sectors?		
7. How do you think could be a good solution to feed the increasing global population sustainably?	-vertical farming	(Bogomolov et al., 2021)
8. How do you think the new Agritech 4.0 supply chain should be organized to improve efficiency reducing waste and foodprint?		(Eashwar & Chawla, 2021)
9. In your opinion, what are other complementary technologies which support AI implementations in the agricultural sector?	-IOT -Robotics -DSS -Big data	(Chiles et al., 2021)
10. What governments should do to stimulate the technological transition in agriculture and solve its problems?		
11. In your opinion, what is the future of the agricultural sector in the next 10 years?	-CEA -elimination of the gap between primary and secondary sector	
12. What differentiates ZERO from its competitors?		
13. Who are the ZERO customers?		
14. What are the ZERO's future project for the next years?		
15. What are the criteria with which to choose where to place a vertical farm?		

Source: our elaboration (2023).

2.4 Findings

Table 2.4 reports the analysis of the common trends and themes that the respondents provided while answering the questions.

In the first question about the AI role in your company, the respondents explained as ZERO is part of the CEA world (Controlled Environment Agriculture), which merges agriculture, industry, and IT; in this context agronomy, biology, electricity, metalworking, and digitalization are completely interconnected. This system of industrial plants of several thousands of square meters are governed by a proprietary software tool able to collect great amount of data, AI permit to read, organize, and understand the data correlation to realize preventive interventions on processes or to optimize the system maximizing efficiency through the research of the best compromise between energy cost and productivity. Moreover, AI predicts and projects the best "recipes of operation" which are based on historical data. These are realized by a virtual agronomist called ROOT. The limit is the necessity to have a great amount of high-quality data, while the advantages are given by the fact that when the dataset is completely rich in data, the AI system can capture things invisible to the human eye. These instruments increase their intelligence and effectiveness as the volume of data increases.

Question two treats the potentiality of a new disruptive agricultural business model, the participants do not believe there is a business model to be destroyed and replaced completely but prefer to reinvent some aspects of the actual agricultural sector. Only some areas could be changed substantially by the use of technology, such as the in this case indoor farming, surely agriculture remains the last sector to have to be rethought with the use of technology, it is a very conservative world still very far from the use of cutting-edge technologies such as AI. According to the interviewed, actually only in some specific agricultural niches, for instance, indoor farming, the AI technology is a fundamental tool, while for almost totally of the farmers, it represents only an interesting tool to read in newspapers totally unrelated to daily operations.

Question three looked at the new business models, according to the vision of the CEO of ZERO, the new business models will be surely driven by the market because the technology permits solving of a problem or a latent need but does not create new ones. To predict the huge primary sector is almost impossible, but the participant is sure that the high-tech technology agriculture will be driven by data which represent the true value of the future. For this reason, the data-driven business model able to collect and discover the value of data licensing results to its users will be the new innovative business model of tomorrow through a pay-per-use revenue model. ZERO is working in this direction licensing data and knowledge to partners who increase efficiency and productivity.

When looking to explain the relationship between AI and sustainability in the fourth question, the participants stated that high-tech technology agriculture increases sustainability through the use of AI because the algorithm focuses on energy optimization. There are water and resources savings which permit to increase both environmental and financial sustainability, sustainability in fact is defined according to logic "less is more."

Question five results explain as the common farmer wastes innovation seeing it with great scepticism and maintaining a traditional conservative vision. For this refusal exist a very high level of technological tools illiteracy, especially in Italy, while the situation changes in some countries. In northern Europe countries, the common farmers are owners of large farms which use daily technology massively. Moreover, they continually realize projects and create relationships with local universities to discover new ways to identify solutions to existing problems and implement new technology.

In the sixth question about the AI implementation barriers, the respondents highlighted as, in the Italian case, they are mainly given by the extremely conservative common cultural background and the common historically small farm size which hinder the innovation of the actual business model.

Question seven, which treats food security, the participants underwriter as CEA could be a solution to consider in this context because it produces huge amounts of food with the minimum use of resources such as water and land are increasingly scarce and valuable resources. CEA is not the only solution, actually in the world we have several possibilities, often they are uncomfortable tools such as plants and animal genetic modification for food purposes which permit to realize high protein productions with low environmental impact through the use of technology.

In the eighth question results, the participants discussed the necessity of a short new supply chain concentrated in one place where all the production steps are realized, from the farm to the final and ready to buy product. CEA works following this prospective with the aim to reduce food waste, logistic costs, and carbon footprint. The CEA supply chain is completely located in a place where the product is cultivated, harvested, directly packaged, and distributed with a financially sustainable Km 0 agriculture. The main obstacles is not given by technological tools but by financial sustainability because high-tech systems and highly skilled employees with multidisciplinary knowledge are extremely expensive as well as very rare. At the moment, in fact, there are no training courses that prepare for this type of multidisciplinary professional profiles.

About the nineth question, the respondents highlighted as there is no magic formula suitable for every context and adding AI alone doesn't solve all existing problems. It is necessary to create a project and to build a productive architecture which starting from data knows exactly how to use them and for what purpose. All the different part of the project have to be connected and adapted, in this context diffused IOT, datacentres and any other technologies should be built taking in consideration the final purpose of this ecosystem in a organic way. From the first level of technology implementation to the datacentre which collect data, passing from networking architecture and diffused sensors architecture, it is necessary to project design everything as a whole, only in this way the AI implementation create value. For this reason, actually technologies such as AI, IOT and Machine Learning are absolute prerogative of technological agriculture while they are still very far from traditional agriculture which does not have an integrated ecosystem of technologies.

In the tenth question about government implications, the participants explain as actually, in the Italian government case, it is not grasping the CEA opportunity which could represent an excellent made-in-Italy know-how to export and in which Italy could play a starring role in the next years. The Italian food and agriculture recognition combined with the Italian manufacturing history can convince and attract foreign investors with high levels of appreciation. The main obstacle is the high levels of closed-mindedness to innovation given by the inability to understand how it is possible to make a revolution in the agricultural sector while respecting and maintaining Italian local traditions. Italy could export all over the world its technology knowledge and know-how making huge innovative projects with the government support creating a real new driving sector of Made in Italy.

In the eleventh question results, the participants forecasts that in the next years high-tech indoor farming will be one of the new instruments to replace the need to rethink the agricultural sector although it is not the only instrument. It will be necessary to understand better where this type of technology could be the perfect solution and where other types of different tools are preferable. Surely this type of technology will be considered in the next years when it will move to a stage of maturity representing one of the main tools at our disposal.

About the twelfth question based on ZERO's competitive strategy, the participants explain as the company differs from its competitors for several motivations, first of all ZERO uses an aeroponics method of cultivation while the main competitors use hydroponics or aquaponics methods, secondly ZERO owns a proprietary AI instrument called ROOT and a proprietary modular architecture called "ZERO modular architecture", finally ZERO decided to bet directly on its technology creating continually new partnership and rejecting the idea of selling their technology to third parties.

In the thirteenth question about company customers, the results explain as they are represented by people which periodically consume vegetables and give high importance to the food quality and origin without considering only economic factors. They are driven by sustainability purposes and by products which respect the natural environment minimizing the resources consumption and maximizing the crop yields. Actually, there are three kinds of distribution channels: supermarkets, food companies and Horeca.

About the fourteenth question on future company strategy, ZERO is creating the so-called "Future Farming District" which includes the construction of one of the largest vertical farm of the world in Capriolo, a town located in the Brescia province (Italy). The Future Farming District will be dedicated to a small branded production and a broader partnership strategy with national Retailers aimed at launching private label programs following a mixed strategy. The area chosen to host the district is that of the Oglio Park, a strategic position that allows reaching all of northern Italy, Switzerland, the south of Germany and Austria with short-range logistics. Moreover, the proximity to the system of hydroelectric plants located on the Oglio river, the largest is within the industrial complex, permits obtaining clean energy production with lower costs. The project is much more than a vertical farm because inside there will be some R&D and educational centres to continually develop new innovative solutions, prepare the professional figures required by this sector and especially educate young people, which will be the customers of tomorrow, about the new future farming trends. In this way ZERO proposes to reduce cultural backwardness and scepticism to innovation since youth to have a tomorrow conscious consumers.

In the fifteenth question about the vertical farm location criteria, the respondents explained as they are typically financial motivations because vertical farming cultivations are technically location independent. These economical and financial criteria are given by the optimal trade-off between the proximity to distribution centres, with the purpose to minimize logistic costs, and the proximity to plants that produce energy from renewable sources, with the purpose to minimize energy costs which represents the higher part of vertical farms operating expenditures.

Tab. 2.4 Analysis of common themes and trends.

Interview question	Answers
1. Which is the AI role in your company? Which agricultural problems could be solved with AI? Explain an advantage and a disadvantage of AI implementations within your company?	- AI for preventive intervention - Maximize efficiency through the research of the optimal point between energy cost and productivity. - Predicts and projects the best "recipes of operation" based on historical data. - Limits given by the need for great amount of high-quality data needs. - Advantages given by the possibility to capture things invisible to the human eye
2. Do you think AI has the potential to disrupt the actual and create new business models in agriculture?	- Better to reinvent some aspects of the agricultural sector with respect to disrupt - AI actually just in some high-tech agricultural niches, such as indoor farming
3. If yes, what are in your opinion new possible business models in the agricultural sector? Are they technology-driven or market-driven?	- Market-driven - Data-driven business model able to collect and discover the value of data

	licensing results to its users through a pay-per-use revenue model
4. Do you think that AI improve the farm sustainability? On which way?	- AI for energy optimization, water and resource savings
5. Do you think that farmers have the right level of ICT knowledge to exploit efficiently AI? If not, what could be some initiatives to solve this problem?	- High level of technological tools illiteracy as a consequence of innovation scepticism and conservative values - Heterogeneous situation around the world (for instance northern Europe countries) - Create and maintain continual relationships between farms and local universities.
6. What are the main barriers which hinder the AI implementation in the agricultural sector? Why is there backwardness concerning other sectors?	- Common cultural background - Farm size
7. How do you think could be a good solution to feed the increasing global population in a sustainable way?	- CEA - Plants and animal genetic modification for food purposes
8. How do you think the new Agritech 4.0 supply chain should be organized to improve efficiency reducing waste and footprint?	- A short new supply chain concentrated in one place, from the farm to the final product. - Lack of multidisciplinary knowledge, high costs of technology and skilled employees are the main barriers
9. In your opinion, what are other complementary technologies which support AI implementations in the agricultural sector?	- Adding AI alone is not enough. - Need to project and build an ecosystem of productive architecture
10. What governments should do to stimulate the technological	- An excellent made-in-Italy know-how to export and in which Italy could play a starring role in the next years.

transition in agriculture and solve its problems?	- Government support to build a new innovative proposal starting from tradition. - Innovation is not the opposite of tradition
11. In your opinion, what is the future of the agricultural sector in the next 10 years?	- High-tech indoor farming as one of the new instruments to replace the need to rethink the agricultural sector in the next years
12. What differentiates ZERO from its competitors?	- Aeroponics method of cultivation - ZERO modular architecture and ROOT
13. Who are the ZERO customers?	- People which give high importance to the food quality and origin - Distribution channels are supermarkets, food companies and Horeca
14. What are the ZERO's future project for the next years?	- Future Farming district - R&D, young people education
15. What are the criteria with which to choose where to place a vertical farm?	- Economical and financial criteria - Proximity to distribution channels - Proximity to plants that produce energy from renewable sources

Source: our collaboration (2023).

2.5 Discussion

The results show an instance of a company really focused on an actual small niche of market which try to replace the unanswered problems of traditional agriculture with a new innovative and technological value proposition. In this context, AI plays a leading role allowing, together with an ecosystem of integrated technologies, to realize a new concept of agriculture free from climatic conditioning, pathologies, and uncertain yields. Vertical farming is a branch of CEA and is proposed as one of the possible solutions to the increasing global population expected to reach 9.7 billion in 2050, producing food in a sustainable way.

According to the CEO of ZERO, vertical farming is only a niche of the market not because it represents a new trend, the practical invention dates back to 2008, and not even because the technology is not developed enough but instead because actually, vertical farming is not financially sustainable. Every business project must have a business model with an income statement creates value, starting from this point ZERO tried to changing the rules of the game with a new business model based on AI and modular architecture which differentiates ZERO from its competitors.

AI inside ZERO is part of an integrated and organic ecosystem of technologies, the company created a proprietary artificial intelligence algorithm called "ROOT" which starting from a massive amount of operating data, measured continually, is able to act immediately in the farm with preventive interventions. The instrument is created with the purpose to understand and react to different situations by providing support to all agronomic decisions within the farm, for this reason ROOT is also called "The virtual agronomist". This instrument continually collects and process operating data from the cultivation with the use of IOT systems and day by day increase the accuracy of its forecasts by updating "the ZERO recipe" and achieving better performance. The goal to be achieved is to find the point of maximum efficiency that allows to maximize productivity while minimizing electricity consumption, in this way the company achieves both economic and sustainability goals providing a clear example of how these two can coexist. Energy consumption, in fact, represents a substantial share of corporate opex as well as the greatest environmental impact of the vertical farm, for this reason, as explained by Dr Modesto, the ideal place to build these production facilities is near renewable energy sources to minimize the energy cost.

This ecosystem of integrated technologies, which combine AI, IOT and other components, permits to reduce personnel costs of manual workers who collect data and process it on traditional farms at the same time, as highlighted by the CEO of ZERO during the interview, increases the demand for high skilled workers with multidisciplinary know-how including agronomic, mechanical, biological, and digital knowledge. These profiles are unavailable in the actual market of work and people with these characteristics are very expensive, for this reason we can highlight as this new business model of high technological agriculture reduces the quantity of workers while increasing the quality of them. Precisely because of this difficulty to find suitable workers, in the new project of ZERO called "Future Farming District" the education and training of young people cover a part of considerable importance. Moreover, in this context the collaboration between companies and local universities plays a fundamental role with the need to create a new business-oriented teaching model.

Although the intensive use of technology could suggest that in the ZERO business model the primary resource is the technology itself, the real competitive advantage is given by R&D and above all, by human and intellectual capital. These represent the distinctive resources which allow the company to continuously find innovative solutions. ZERO, through its farms, sell its products mainly to wholesale, supermarkets, and food companies but this is not the company value proposal. ZERO could sell any product to any customer, the real and true core competency is the ability of the company to produce an high-quality chemical-free product, more than organic, at a competitive price with organic products while maintaining the financial sustainability of the project. This is the motivation which convinced ZERO to build its revenue model based on the investment of its technology instead of on the sale of the same, in fact, ZERO works a technology provider by licensing its resources to its partners but remaining the owner. In this way ZERO works as a holding with several partnered farms on which invests providing technology, such as the proprietary "ZERO modular architecture", knowledge and especially data, in return every year ZERO reaps the rewards through dividends and royalties.

This model follows the vision of the CEO of ZERO according to which in the next years the new business models in the agricultural sector will be data-driven business models on which a company, owner of great amount of data and the AI software to process it, will license the results to its customers with a pay-per-use revenue model. In this way the companies, also small and medium-sized enterprises which do not have internally available great amount of data, the expensive technological instrument to process it and especially the necessary know-how, will have a DSS driven by AI to support their business decisions in an always more complex and faster world.

This concept is added to a series of several consideration which clearly detach the CEA world from the traditional agriculture, as highlighted by the interview participants. We can speak about AI in agriculture today only in some niches of market where we can have large amounts of data to analyse, such as vertical farming, they represent a drop in an ocean compared with the totality of the agricultural sector. The primary sector therefore remains the only production sector to be reinvented with the use of technology, reducing the existing gap with the industrial sector with a view to a new industrialized agriculture which permit to increase productivity reducing the resource consumption.

According with the respondents several factors hinder innovation and change in the agricultural sector but especially the cultural backwardness and the lack of financial resources. The situation is very heterogenous around the world but even within Europe with northern countries farms much more technological and innovative than southern countries farms with a consequent resulting in a different approach to innovation.

The high levels of closed-mindedness in some countries derive from a strongly conservative ideology that sees innovation with scepticism especially in a highly traditional sector such as agriculture, for this reason in the new "Future Farming district" ZERO will organize days dedicated to the education of children who will be the consumers of tomorrow.

This heterogeneity between countries could be explained by the fact that in countries with a harsher and unsuitable climate for agriculture, technology is the only option available, while in historically fertile countries such as southern Europe, traditional farming is still an appropriate method of cultivation and only a few incremental innovations have occurred. Another explanation is that the entrepreneurial fabric is completely different with large high-tech farms in the north Europe and small or medium-sized farms still strongly traditional in the south, for this reason the latter do not have the financial resources to invest in innovative technologies that are highly expensive. These small and medium farms in the next years will have to come together to take advantage of the opportunities offered by technology without being crushed by competition from large farms.

In the last periods climate change and lack of water are becoming topics of public interest and the need to rethink a new agriculture seems to lead towards solutions similar to those reported on these pages. In Italy there are some players of this new concept of agriculture, such as ZERO, but actually the Italian government is not investing on this niche of market fearing that innovation in agriculture could affect the market of traditional Italian products recognized worldwide. According to the CEO of ZERO, tradition is not the opposite of innovation, on the contrary, it is a matter of building a new innovative proposal starting from tradition, while leveraging the recognizability and authenticity of our local tradition.

CEA is not a substitute proposal for traditional agriculture but on the contrary, it wants to extend the agricultural sector beyond the boundaries imposed by nature and climate with a large sustainable industrial intensive agriculture. Taking advantage of the credibility of Made in Italy, Italy will have in the coming years the opportunity to create a new sector of agriculture guided by knowledge and technology with the opportunity to export the know-how of Italian companies all over the world. This type of agriculture free from location can be exported to countries where traditional agriculture is impossible due to climatic conditions, with energy sources available it is possible to grow in the desert, in Alaska and anywhere you want.

The Italian government should support this new market in a better way than it currently does, in fact, today there are several non-repayable calls for technological agriculture and agriculture 4.0 but they are slowed down by bureaucracy with the result that in a faster and faster world, before receiving the funds to make investments the technology in question is already obsolete. In the next year climate change and need of food will force the governments around the world to find some solutions, CEA is only one of these. Italy can act proactively with respect to reactively anticipating change and entering a booming market with a role of first mover, as it was unable to do with the wave of the fourth industrial revolution. In particular, the government should invest on small highly innovative companies which are the real sources of innovation, and which will then be incorporated within the main market players.

This model of short and integrated supply chain, as explained by the ZERO case, has huge possibility both from the economic and the sustainability prospectives. Beyond the already mentioned low environmental impact and the reduction of waste along the supply chain, this method of cultivation permit to produce locally some products which are historically imported from abroad with a real change of course, from globalization to localization and km0 production. The possibility of having a fresh product anywhere in the world produced locally was only a utopia until a few years ago. In Italy the challenge is to bring back locally the production of the coffee, cocoa and cotton creating integrated and short supply chain of typical products of Made in Italy such as coffee, clothing and chocolate.

Conclusions

This case study explains as although vertical farming actually represents only a small niche of market, it has the potential to solve some of the main agricultural problems, including food security. ZERO is a clear example of how starting from a problem, in this case the financial unsustainability of vertical farming, it is possible to arrive at a solution with a new business model in which AI plays a fundamental role. Starting from the premise, highlighted in the structured literature review, that in the academic literature there is a gap of business models that are discussed but only rarely mentioned, the ZERO case study provide an instance of a potential ideal business model with a qualitative approach.

New research should focus on a comparation between ZERO and other players of this niche of market to better understand other possible business models using the same semi-structured interview methodology and the same research protocol. An example of an Italian competitor company could be Planet Farm based in Cavenago di Brianza.

Entrepreneurs should invest in this sector which expected to grow substantially in the next years, climate change policies and PNRR (National Recovery and Resilience Plan) in Europe are focused on ecological transition with more sustainable agriculture. This paper show an ideal business model to follow in the vertical farming sector which invest continually on R&D and intellectual property without selling the company patented technology to third parties, in this context AI cover a leading role.

The governments should invest in this niche of market to gain a competitive advantage in what could be a potentially immense market in the coming years and building a new driving export sector.

As with all studies, ours has limitations. Even if the methodology can be considered rigorous, firstly it focuses only on one company located in Italy and for this reason country-specific or organizational-specific elements might affect the findings. Secondly, we used a qualitative approach which permits us to capture more detail that a large-scale studio would not be able to do but at the same time there may be several biases caused by the possibility of misinterpretation. Moreover, the speed of technology development in this interesting sector reduces the life of data that becomes old very quickly. Such limitation may lead to further research opportunities with periodic reviews.

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