Deep Science Publishing
https://doi.org/10.70593/978-81-988918-5-3_11

Chapter 11: Cross-disciplinary learnings from agricultural technologies for healthcare data management

11.1. Introduction

Agriculture is a data-rich industry and one of mankind's earliest commercial pursuits. Commercial agriculture utilizes modern technology innovations, terminology, and business concepts. Like successful businesses in any other sector, commercial agriculture businesses also need to be responsive to their stakeholders and stay at the cutting-edge of their field—and related fields. It is logical that best practices from one data-rich business sector can be learned from and easily applied to other data-rich business sectors to improve the bottom line. Healthcare data management has always been a data-driven and data-rich industry with urgency to analyze data and convert the data into knowledge for healthcare-related decisions. The need for accurate, secure, and efficient healthcare data management has been amplified by the pandemic. Commercial agriculture firms had also sped up the large-scale adoption of blockchain and digital ledger technology in their everyday operations during leap years (Comi et al., 2023; Eigenbrode et al., 2024; Mittal & Bansal, 2024).

Increasingly interconnected, shared, and battleground environments are very much present in healthcare data management, commercial agriculture, and other business sectors. Information lifecycle management, security protocols, and rare but impactful data security incidents are well-known concepts in both the agriculture and healthcare sectors. There are many commonalities with opportunities to collaborate and share new solutions across verticals. Commercial agriculture can improve harvesting methods and further increase food resilience and return on investment if the solar energy harvest information from the energy sector is compared with the food yield harvest data for return on investment calculations. The two conclusions from these past but uncommon matches are that: business sectors with different end products and target customers share many of the same operational challenges, and challenges are often better addressed with customizable solutions based on existing solutions from a different or different business sector (Shanableh et al., 2022; Roshania et al., 2023).

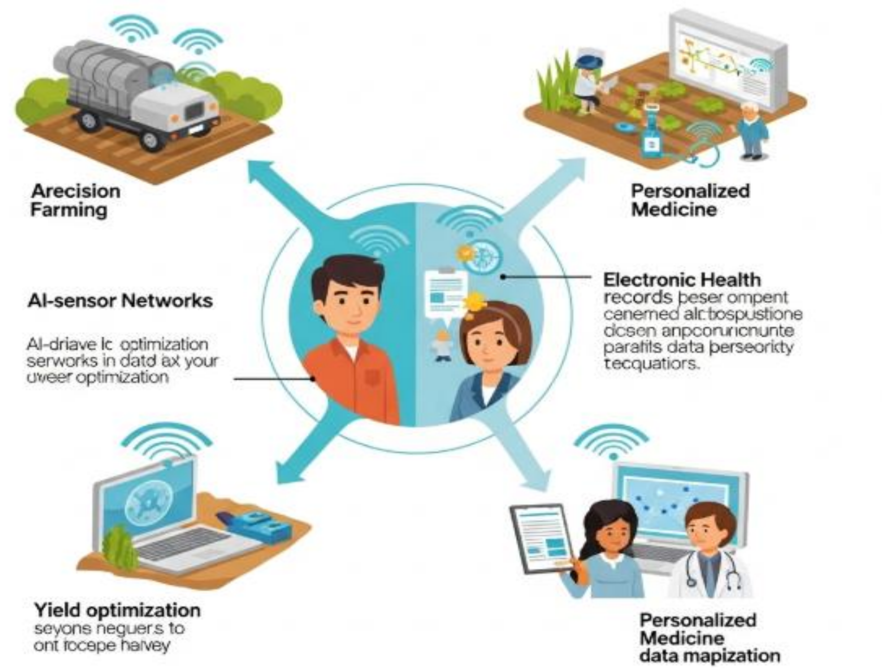

Fig 11.1: Agricultural Technologies for Healthcare Data Management

11.1.1. background and significance

We live in a world of data. The Internet of Things, transactive energy, or smart homes all are producing incredible amounts of data. Yet, the burden of creating and maintaining the systems that manage that data often falls upon inadequate resources. This is common across sectors. For example, managing patient records in hospitals is overly complex, controlled by difficult-to-use vendor-proprietary systems with limited communication capabilities. These limitations are well known. The same issues are encountered in the food and agriculture supply chain. Product control and information sharing are enhanced by data management systems. These, however, similarly depend on easily used tools and standardized formats while also conforming to data control requirements.

Search, retrieval, and sharing of sensitive information in the healthcare sector is targeted for improvement of user access with strict data privacy and security provisions. Similarly, issues of excessive and costly storage, difficult sharing and often lack of data control are key concerns of the food and agriculture sector. In both sectors, technology developments have promised better solutions. These include blockchain, cloud-enabled applications, and interoperable APIs. However, so far, the promise of technology has not been realized. Both healthcare systems and food agriculture systems have seen uneven levels of success for improvements, which has resulted in stalled attempts to overcome existing challenges to implementation.

Standing alone, these characteristics may not be sufficient to promote cross-discipline transfer of lessons learned in efforts to utilize technology for the development of easier-to-use data management solutions. There are, however, similarities that may offer some lessons. Using case studies, we draw upon these to illustrate cross-disciplinary opportunities and what has been dubbed the "cyclical economic economy" where resources are under pressure. In both cases, acceptance of near-term solutions that fall short of what might be an optimal industrial-wide solution may be expensive, but perhaps more feasible than waiting for the more costly comprehensive systems that postpone solutions for individuals and small entities.

11.2. Overview of Agricultural Technologies

As early adopters, agriculture can deploy several technologies earlier than other industries. Systems such as AI, area networks and mobile infrastructure, blockchain, the Internet of Things, and Robotics operate extensively in agriculture. As a result, it can be beneficial to observe how agricultural technologies work in practice to affect the acquisition of scarce resources, how they can advance with the support of regulations, standards, and public policies, what challenges they present for investors, or what business models they allow for growing companies. Even direct transfers from agriculture to healthcare may occur, as in the case of drones and processing platforms used in supply bodies for the testing of vertical structures. Using a grounded approach, we first describe and compare actual or available technologies for agricultural applications. The description emphasizes the technological characteristics that lead to the extension of their use. The comparison is based on aspects beyond the pure specifications, rather geopolitical optimistic and pessimistic views on their reliability of deployment, including the availability of human resources for development, deployment, exploitation, and management of the technology. Further reasons to consider are industrial strategies and plans to make these ecosystems available as industrial solutions; synergy effects on prices with other applications; and the presence of deep pockets to face involvement. Through the analysis, we aim to provide the groundwork for the further decision to observe the developments in the agricultural ecosystem and to favor the transfer to healthcare. Questions on timing, type, and intensity of technology transfer between agriculture and healthcare are posed.

11.2.1. Research design

The analysis considers reports, papers and books related to agricultural technologies and healthcare data management. The reason for this extensive review of the literature is both pedagogical and methodological. The pedagogical objective is to demonstrate the nature of the research that has drawn our attention towards agricultural technologies, which has motivated, influenced and, ultimately, led to the present comparative analysis. The methodological objective is to consider as relevant all of the studies that have invested efforts to gain understanding and build insights around the design, development, implementation, use and appropriation of technologies in these two sectors, irrespective of their nature, content or more or less elaborate structural model, or the domain and area of specific application, or the geographical context and socioeconomic conditions; focusing instead on the generative and formative process of the knowledge-building cycle.

With respect to the former, performed mainly through keyword searches, we focused on publications from the last forty years, being consistent with the scholarly, methodological and theoretical consolidation of technological studies. In the case of agricultural studies, the following keywords were considered: “agricultural technology”, “agricultural design”, “design according to FBS”, “agricultural architecture”, “agricultural engineering”, “agricultural machine”, “agricultural machine design”, “agricultural system design”, “agricultural structure”, “agricultural technology”; and for the healthcare sector: “healthcare technology”, “healthcare technology design”, “healthcare technology architecture”, “healthcare technology engineering”, “healthcare technology use”, “healthcare technology system design”, “healthcare architecture”; as well as exploratory combinations of some or all of the keywords.

11.3. Data Management in Agriculture

Data management in agriculture has a storied history dating back thousands of years. The first known data stored in some manner came via knotted strings in the Incan empire, where quinoa was managed, and impressed clay tablets in the Mesopotamian civilization, where barley was developed and cultivated, enabling modern civilization. These civilizations' main crop data was needed to manage agrarian taxation systems. Over time, and with the advent of modern computing, data management in agriculture has evolved to enable better crop and soil management to feed the world. Farmers primarily utilize two different mechanisms to collect data – sensors on vehicles and sensors in the environment. Data management in any field generally focuses on appropriate sensor and platform use and methods to analyze collected data. Intelligent data management techniques in agriculture initially primarily consisted of threshold value comparisons against the data collected, but have since evolved into machine learning techniques applied to data from different farms and crops around the world.In agriculture, utilization of sensors on vehicles generally occurs when the object of study is not able to be left in its environment. These sensors are often known as proximal sensors, as opposed to the outbound sensors, known as distal sensors. The data collected from these proximal sensing campaigns can be utilized in several methods, including data fusion methods, photogrammetry and computer vision methods such as those employed in site-specific management zone determination and 3D point cloud generation, and/or machine learning methods with grouped data collection. These methods enabled crop data generation for better management of specific crop growth periods, such as flowering detection for soybeans via combine harvester canopy height data.

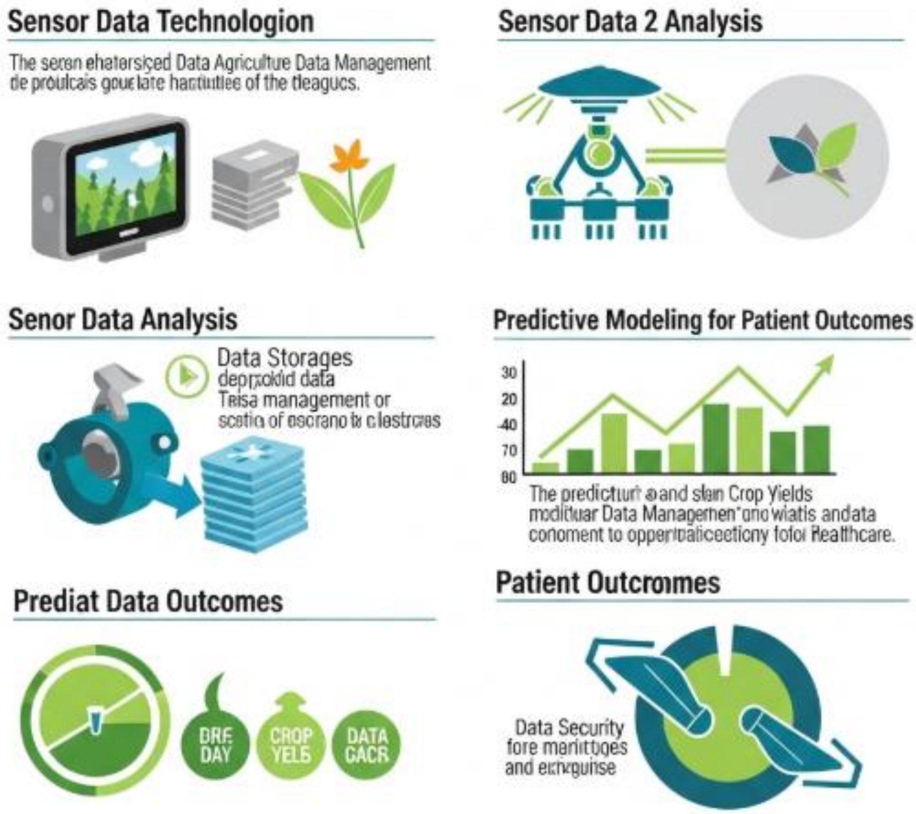

Fig 11.2: Data Management in Agriculture

11.3.1. Data Collection Techniques

Successful biomedical and health profiles are enabled by many of the stages performed in agriculture. In agriculture, the initial stage in the data pathway is the collection of pertinent data, frequently via use of smart sensors. This method is similar to biomedical sensors, which often take the form of wearables. Wearable sensors for biomedical and health purposes have the advantage that they are small, inexpensive, and can be placed directly onto individuals. They can also be used in longitudinal studies. Similarly, for farming purposes, sensors of many different types have been developed and validated for many different applications. Examples include: meteorological data collection to optimize crop germination, root-level moisture monitoring to schedule optimal irrigation and fertilizer usage, soil moisture and temperature monitoring to optimize crop growth, in-paddock networks for livestock, emission traps to study pollen movement and disease transmission, capture of animal movement and foraging behavior using accelerometers and GPS collars, measurements to map soil variation in nutrient and moisture availability, remote satellite-based sensing to determine groundcover and leaf area index, monitoring of crop phenology to trigger herbicides, mapping of machinery capacity and play to schedule harvest, nondestructive on-ground crop and fruit analyzers based on spectroscopy, and machinery-based yield extraction mapping to measure harvest efficiency and losses.

11.3.2. Data Analysis Methods

Data analysis is where making sense out of the data comes in; and different stakeholder strips of the data will want different aspects of information. For example, a farmer may want to know how to modify his farming practice to get it right this season; whereas the agri-businessman may want to know how to make better investment decisions and the government may want to know how to prioritize surveillance for diseases. When the intended use becomes clearer, the various statistical approaches to data analysis will be favored differently; and may need adaptations as in making prediction and communication easier; and designing efficient elicitation instruments. Bayesian statistics and econometrics are two statistical branches that have matured around these very different concerns.

Coming to the different components of an analysis pipeline, basic and advanced statistical functions such as modeling and learning frameworks, graphical analysis functions such as multi-dimensional projection techniques, color- and shapes-encoded perceptual variation functions; widely different mapping and filtering framework functions, including Geo-spatial interface modules for both visual and statistical functions, high-performance and custom parallel processing capabilities, and read-write interfaces to any popular data capture devices and persistence formats are all needed by anyone. While some of these functions will be minimal and intuitive for simple processing usages, they will of course be richer and flexible enough for design and development of more complex analyses, involving tasks such custom query processing or shared, hybrid work-distributed analysis with collaborators.

11.4. Healthcare Data Management

Data management in healthcare includes all tasks needed to collect, store, protect, and enhance the value of health data, allowing insights into healthcare delivery and health. Healthcare data has several specific characteristics that influence its management. The amount of healthcare data is huge, growing significantly over the years. It is heterogeneous, originating from multiple sources, including informational systems for billing and financial management, electronic health records, and telemonitoring systems, among others. It comes at variable speed, in variable formats, and in variable data models. Data collects sensitive information on patients and has a strong identification of patient's data. Healthcare data is difficult to interpret, being the result of complex procedures. Important biases can affect both the quality and the use of healthcare data. Nevertheless, these challenges represent the potential of using it to help make decisions that will improve population health. However, although risk management has been gaining importance in healthcare management, the importance of correct and efficient data management is still overlooked.

Some important uses of healthcare data include retrieving medical interventions to study their clinical effects, using hospital readmission records for selecting and prioritizing targets for hospital readmission reduction initiatives, and exploiting health data to conduct surveillance, policy, and preparedness decisions relevant to reducing the impact of public health emergencies on health services. Big data analytics is increasingly being integrated into hospitals and healthcare systems to help executives analyze business performance and improve clinical service and operational workflows.

11.4.1. Importance of Data Management

Healthcare data management refers to all tasks associated with the storage, control, sharing and analyzing of healthcare data. Effective data management can assist in making better healthcare decisions, improving efficiency, and enhancing patient outcomes. Additionally, applying data management tools and techniques can increase data quality and modernize outdated technologies and systems. Healthcare organizations need to manage and deploy tools that analyze and transform data into meaningful information. This information can support quality improvements and impact the overall delivery of care. At the same time, the healthcare industry understands that data management is a complex task in a wide variety of settings. It has diverse systems producing data related to patients' care such as clinical and claim records. Healthcare companies are pivoting to create a data-driven decision making and analytics environment. They have started using tools like predictive analytics, big data, and data warehouses. However, such tools need to be driven by adequate data management systems and processes. Due to the complexity of the data involved and the importance of patient care, a combination of systems and processes is required to be effective and efficient.

11.4.2. Current Practices in Healthcare

A complex healthcare data ecosystem, one that possesses more intricacies than the sector itself, has emerged as a result of healthcare service providers being required to satisfy a wider range of expectations from a wider, heterogeneous group of stakeholders. Patients, physicians, payers, academic researchers, and pharma and device firms all have various and evolving expectations of the sector, as do regulatory institutions. As a consequence, a few crucial factors are affecting the Healthcare industry:

The enormous volume and variety of data that is generated and/or collected, resulting in the manifold mismatch of data and needs among different stakeholders. The manifold level of privatisation of the industry, which reflects on a delicate balance of interests among profit making by stakeholders and the health of individuals, who are indirectly subsidising these profits. Access to services for every individual and delivered by the best specialist, wherever located. Asymmetry of information at the time of diagnosis and prescription. Value and cost of healthcare services made explicit. The efficient and effective management of Healthcare Services Data (HCSD) assuming legal, ethical, and technological perspectives is of prior importance because it binds and enables the above factors to be addressed satisfactorily.

We briefly describe the type of data governed in the industry, the various stakeholders and their concerns and needs related to HCSD, and the actual status of HCSD. The industry's data troves are maintained as silos, managed by a variety of potentially contradictory systems, varying from Supplier to Customer Relationship Management systems of device and pharma giant firms, conventional Insurances firms Data and Analytics systems for portfolio management, and enterprise-wide ERP systems implementing guidelines for their Client and Services Provider Data and Relationships.

11.5. Comparative Analysis of Data Management

Healthcare data and agricultural data have vastly different characteristics. Healthcare data is primarily gathered and utilized for individual patient-centric applications whereas agricultural data is used for multiple repository-based analytics involving thousands of users. Healthcare data management is involved with real-time events during patient treatment, although people can be treated for days or even months. The data-driven applications in healthcare are mostly focused on individual patient analysis using some degree of machine learning or analytic tools. Healthcare is a largely unstructured and personal data domain, and innovations in relation to patient data are often driven by the financial interests of private organizations, but the products are not generally available for other researchers.

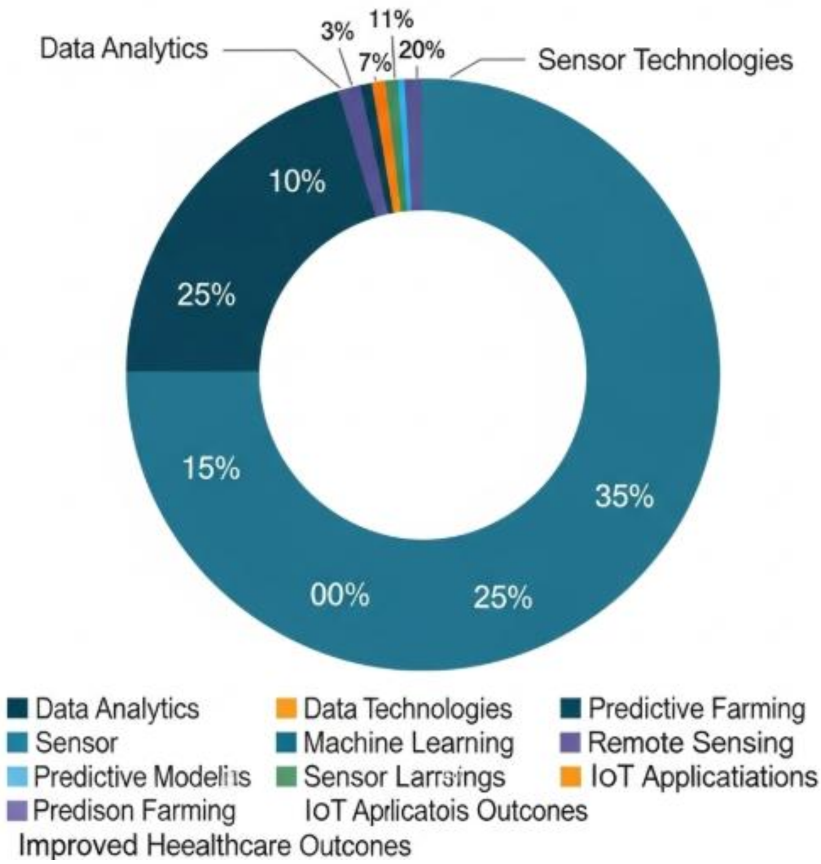

Fig : Cross-Disciplinary Learnings from Agricultural Technologies

In contrast, agriculture deals with events over the life cycle of crops from planting to harvesting and beyond into processing, usage, products and financial support. Agricultural work is mostly seasonal and evolves in multiple stages into a full-fledged life cycle driven by natural climate conditions. The exploitation of agricultural data focuses on multiple types of processed cloud-based analytics encompassing the entire society. As a consequence, the criteria for innovations in relation to agricultural data are mostly determined by the market forces as they tend to provide an overall available beneficial ecosystem, goodwill and collaboration incentives for the stakeholders. The issues to be addressed in agricultural data management are perceived as “scientific” problems which have deep analyses with long term focus, discussed in peer-reviewed forums, and are constantly being developed into advanced novel solutions over the years.

Data acquisition of such high possible quality is crucial, since low tax quality will result in arbitrary low policy effect estimates that are equal to or even exceed the actual effects. In other words, misguided data will jeopardize any decision taken, as it is said – "garbage in, garbage out". The need for evaluating external validity of findings derives from the long-recognized belief that the conditions under which a clinical trial is undertaken may differ markedly from those in everyday clinical practice, thereby affecting the interpretation of trial results.

11.5.1. Data-Driven Decision Making

Data-driven decision-making enhances integrating, correlating, and analyzing data across silos in order to support key-making strategies. Similarly, new agricultural technologies have increased the need for data-driven decision-making in dissemination and analysis of healthcare data. These key areas of healthcare data-driven decision-making rely significantly on data technology, however, like those support systems based on the principles of precision medicine, it is not all about data. Some of the critical drivers enable quality-driven data acquisition, large-scale analytics, acting on time, visualizing for insight, socio-technical issues, serious inadequacies of real-world evidence generation or interest need for alternative methodological frameworks.

Despite the fact that the major driving force behind healthcare research is to improve societal welfare, like in agriculture, the result of precision medicine research, is unfortunately often sub-optimized only to serve the benefit of a few large healthcare entities. The trade-off between data protection and data-driven healthcare innovation centers around the balance between the need for real-world evidence in order to understand and mitigate possible negative consequences of new treatments and the intention to protect privacy of individuals.

11.6. Technological Innovations in Agriculture

"Growing progress forms the basis of our world and our everyday life. Everywhere you look, there are farms which produce the food that we eat after a tough workday; places which feed the world and shed light on how businesses work. For centuries, agriculture has been the basis for developments; creating economic expansion, especially when it comes to cottage industry. But in recent decades, it has turned into a global economic topic. Besides handling the world's food supply, agriculture plays an important role in the world economy, too. It can make a difference for countries to achieve growth and development. Today, around a third of the planet's workers are employed by this economy sector and developing countries still continue to rely on agriculture for their economic progress. Founded in the constant challenge of improving know-how and technology, expert groups from different universities and industry have worked behind the scenes to prepare for the future. Fueled by an innovative spirit, these agricultural scientists have opened every door. With the help of cutting-edge technology, they are developing new ways of precision farming, supply chain management and cold chain tracking within agriculture. This know-how can now be used by other industry sectors, as fields become smart factories. Cloud- and web-based technology systems do not need to be limited to agriculture use; new business models can now be implemented and the established solutions can be applied in several areas. Why not use all that agricultural experience in other fields, too? After all, products from agriculture are also the starting point for several industry sectors and services."

11.6.1. Precision Farming

Many of the information technology advancements taking place in healthcare are also occurring in production agriculture. Examples of these technologies include remote-sensing, real-time networked databases, data mining and modeling, global positioning systems and geographic information systems. These advancements are collectively referred to as precision farming, smart farming, or site-specific crop management. Problems in health informatics, decision support, and operations management, for example, can benefit from research in these precision vermiculture technologies. These technologies have enabled policymakers, farmers, scientists, and plant pathologists to work in partnership in addressing the challenges facing agriculture in the 21st Century. In addition, these programs are aiding farmers and rural communities in creating innovations to maintain a successful economy and quality of life, while preserving the environment.

Precision farming can be characterized by two major transitions in U.S. and world agriculture. The first transition is a movement from a commodity-based agricultural economy to a knowledge-based economy. Like most other industries, agriculture is moving from a commodity-based economy that relies on cheap raw input and high-volume batch processing to a knowledge-based economy that relies on differentiation, customization, premium pricing, and the rapid production of high-quality, value-added products. Information becomes both a productive input and the primary medium of exchange in the knowledge economy, rather than a barrier or by-product. As information technology advances, productivity among agricultural producers in the U.S. will depend less on new machinery and more on new information systems, narrowly tailored to meet the needs of users of information in agriculture.

11.6.2. IoT Applications

IoT Applications in agriculture concern both plantation farms and livestock farms. Some IoT applications employed on plantation farms include land and crop monitoring systems. Usually, those systems use different kinds of sensors — air temperature and humidity sensors, soil temperature sensors, soil humidity sensors, light intensity sensors, gas sensors, and/or video/image sensors. From analyses of the collected data, farmers can make predictions of the crop yield and detect irregular situations, like forest fires or predicted weather conditions during harvest. IoT applications for plantation farms also contain systems tracking physical data and bioinformation of field equipment. Such data can provide farmers with information regarding the efficiency and status of machines.

Usually, those bioinformation systems consist of RFID and/or wireless sensors. Other IoT applications for plantation farms include weather and irrigation control systems. Weather systems are data collection stations that are weather predictors used for agriculture. Irrigation control devices can control irrigation remotely. In addition to the above-mentioned IoT-based precision-farming systems, devices that monitor soil parameters, temperature, humidity, light, and/or CO2 concentration could be used to check if crops are in a suitable environment for growing.

The livestock farm IoT applications focus on the tracking and monitoring of the livestock operations by brand detection; heart rate detection; temperature, humidity, and gas concentration sensor data monitoring; RFID information remote access; and so on. This tracking and monitoring task for livestock farms are achieved with a few technologies, such as RFID sensors, GPS sensors, and wireless sensors. The main applications of these technologies include monitoring animal behavior and housing environment, disease prediction, event detection, health check, and animal food control. Most of the livestock data is animal bio-information downloaded from the RFID systems.

11.7. Conclusion

In this chapter, we have discussed the overlap of conceptual foundations and methods between the management of agricultural transport investments and the management of healthcare data, focusing on both issues of intent and implementation and the useful metaphorical borrowings that can be made. The reason for exploring this otherwise odd adjacency with the two fields sharing no apparent link besides their management-related needs is the power of symbolism as analogy in our study of both fields. Furthermore, we proposed some sample exercises on issues in the management of agricultural investments for strategy formation and shaping that then returned to the management of healthcare data to update our understanding of it. The exploration and exercises are enviably mostly low-involvement instead of economically burdensome. This final section considers anticipated further research, extending the exercises to other actors engaged in the ethical, redesign, or speculative futures tasks of technology or health management. Emerging research horizons focus on the re-establishment of fabric and documents underlying both technologies, undergirding proximity opportunities along multiple dimensions for actors across the two fields, and drivers of change that can be shared along respective subcategories in the two domains.

Anticipating resets of various sorts on both fronts, we can project at a high level that prospective parameter updates in agriculture will spur changes in management focus within healthcare. These changes could yield prompts or even shocks for forgeable pathways and guidelines that traverse both domains. Ultimately, we see expanding feedback loops, wherein the resolution and potential sharing of externalities for actors in one domain can impact the behaviors of the others' actors, which in turn change the resonances involved in their own echo.

11.7.1. Emerging Trends

According to Moore's Law, every in silico process can exponentially increase its power over time. Healthcare data management – from the HTA stage all the way to patient diagnosis and treatment – is increasingly relying on powerful in silico cycles to accomplish tasks that otherwise would not be possible. Ag-tech has similarly been on an overall trend toward digitalization. However, because of the actual physical cycle of plant and animal growth, much longer than the in silico cycle, this aspect of food production is longer in becoming digitalized, and lacks the overall flexibility of in silico applications and platforms. In addition, not all aspects of food production can be easily digitalized and moved to the disembodied cyberspace.

Healthcare currently evolved unilaterally toward disembodiment in cyberspace. Data related to healthcare are increasingly being managed by software products, with those of big data analytics combined with AI capabilities leading the way. Specifically, the focus so far has been on discovering correlations using different forms of Machine Learning. With the upcoming exponential increase in the precision of outcomes based on the Power of Comparison of different realities, the time will come for large health-data assisted clinical trials. To design such a virtual clinical trial, Health Techs will utilize the specialized services of healthcare outcome comparators.

Ag-tech, having longer access to what is physically deterministically different because of factors other than physical disembodiment, is poised to bring its lessons learned to the Health Tech development process. Using the lessons learned from exploring a multitude of technology-based services, the Healthcare sector will also be able to provide Ag-Techs with the lessons learned from hyperspecialization, Cyber Physical Niche Disruption, and Biologically Physical Niche Disruption.

References

Shanableh, A., Aderibigbe, S., Omar, M., & Shabib, A. (2022). Challenges and opportunities of multi-disciplinary, inter-disciplinary and trans-disciplinary research. Higher Education in the Arab World: Research and Development, 311-325.

Eigenbrode, S. D., Eckert, S., Eschen, R., Mbaabu, P. R., Schaffner, U., & O'Rourke, M. (2024). Lessons for the management of cross-disciplinary research teams. In The Ecology and Management of Invasive Prosopis Trees in Eastern Africa (pp. 233-254). GB: CABI.

Eigenbrode, S. D., Eckert, S., Eschen, R., Mbaabu, P. R., Schaffner, U., & O'Rourke, M. (2024). Lessons for the management of cross-disciplinary research teams. In The Ecology and Management of Invasive Prosopis Trees in Eastern Africa (pp. 233-254). GB: CABI.

Roshania, R. P., Yates, J., McIntyre, L., Chancellor, T., Fivian, E., Hill, M., ... & Khandelwal, S. (2023). Assessing needs for interdisciplinarity in agriculture, nutrition, and health education. Global Food Security, 37, 100691.

Comi, M., Becot, F., & Bendixsen, C. (2023). Automation, climate change, and the future of farm work: cross-disciplinary lessons for studying dynamic changes in agricultural health and safety. International journal of environmental research and public health, 20(6), 4778.

Mittal, P., & Bansal, R. (2024). Role of Cross-Disciplinary Collaborations for Holistic Approach to Sustainability. In Community Engagement for Sustainable Practices in Higher Education: From Awareness to Action (pp. 143-160). Cham: Springer Nature Switzerland.