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SUSTAINABLE FARM MANAGEMENT IN THE CONTEXT OF THE SOCIETY 5.0 CONCEPT – CHALLENGES AND DEVELOPMENT PERSPECTIVES

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Purpose: The purpose of this article is to demonstrate how the ideas of Society 5.0 can be translated into the everyday management of a crop farm and what real benefits and limitations accompany this transformation. The focus is on linking digital tools with the environmental, economic, and social objectives of sustainable development, viewed from the perspective of on-farm practice.
Design/methodology/approach: The study adopts a qualitative–quantitative approach in the form of a case study of a single anonymous crop farm located in the Kujawsko-pomorskie Province of Poland. The analysis is based on the farm's operational data (crop structure, yields, records of purchases and usage of production means) as well as a structured interview with the farm owner. The research is complemented by a review of the literature and reports on digital agriculture, Society 5.0, and data governance.
Findings: The case study shows that the gradual implementation of digital tools, which is focused on areas generating the greatest losses, makes it possible to achieve measurable environmental and cost-related effects without full farm automation. The greatest benefits resulted from the organization of treatment records (FMIS), the reduction of overlapping passes through the use of GNSS, and better adjustment of fertilization and crop protection to field conditions. Key barriers included costs, user competencies, and the integration and accessibility of data from machines and systems, including the risk of dependence on a single provider.
Research limitations/implications: The findings relate to a single farm and are not representative of the entire sector. The observed effects may have been influenced by external factors such as weather conditions, changes in crop structure, or production means prices. The value of the study lies in illustrating a practical chain: data – decision – implementation – result, which is relevant for further research on the digitalization of agriculture.
Practical implications: The most important solutions are those that shorten decision-making time and reduce losses that are difficult to detect in the short term, such as overlapping passes, repeated treatments, or incomplete records of field operations. In practice, the key issue is not "more technology" but better control of the production process.
Social implications: Within the logic of Society 5.0, technology is intended to serve people by facilitating work, reducing time pressure and the risk of errors, and ordering documentation. The social dimension of sustainability thus translates into greater predictability of work and a reduced administrative burden.

Originality/value: The article links the concept of Society 5.0 with the practice of crop farm management, demonstrating an implementation pathway from data, through decision-making, to measurable environmental, economic, and organizational effects.
Keywords: sustainable agriculture, Society 5.0, digital agriculture, precision agriculture, crop production, data management.
Category of the paper: Empirical research (case study).

Introduction

Sustainable development is one of the key paradigms of the contemporary economy, integrating economic, social, and environmental aspects in order to ensure long-lasting well-being for present and future generations. In agriculture, sustainable farm management is increasingly rarely understood as "environmental protection." In practice, it means operating in a way that simultaneously maintains economic viability (profitability and liquidity), reduces pressure on natural resources (soil, water, and biodiversity), and ensures social sustainability (work safety, generational continuity, and the stability of rural life) (Wielewska, 2014, pp. 186-195).

In the realities of farm management, these three dimensions often generate decision-making tensions, as cost-effective actions are not always environmentally neutral, and reducing chemical use requires investment and changes in work organization. For this reason, sustainability is not a single figure, but rather a way of "reading" the farm through the lens of data (which can be measured, recorded, and compared) and the consequences of decisions. The better the records of treatments, fertilization, and energy use, the easier it is to reduce losses and risks while maintaining economic viability. Therefore, farm assessment should primarily be based on measures that reflect actual management outcomes, and only in the absence of such data should simplified indicators describing practices or declared objectives be used (FAO, 2013, pp. 3-4, 71). The subject literature identifies as many as 101 indicators of agricultural sustainability, grouped into several thematic categories, which shows that their selection is not neutral and always entails decisions that are important for farm assessment (Bathaei, Štreimikienė, 2023, pp. 1-2). Some Polish studies additionally emphasize that environmental investments (e.g. solutions reducing environmental pressure or investments in renewable energy sources) serve not only an ecological function but also a stabilizing and organizing role in the operation of farms (Wielewska, 2013, pp. 141-150; 2014, pp. 186-195; 2016, pp. 199-206; 2019, p. 105).

In recent years, the classical understanding of sustainability has been increasingly complemented by digital transformation, described, among others, in terms of Society 5.0. In Japanese strategic documents, Society 5.0 is presented as a society that integrates digital and physical spaces in a human-centered manner, in which technology supports the solving of social and environmental problems (Cabinet Office, Government of Japan, 2021, p. 11). The essence of this concept is not the amount of data, but how it is used in the decision-making process while maintaining the primacy of the human role (Narvaez Rojas et al., 2021, pp. 1-2). In agriculture, digitalization makes sense when it shortens decision-making time, reduces losses and uncertainty, and supports farmers in balancing economic, environmental, and social objectives. In a crop farm, this means that data from fields, machinery, and weather are not an end in themselves, but a tool for improving decision quality – when to enter the field, what rate to apply, where to respond first, and how to document operations without adding unnecessary bureaucracy. This process is accompanied by growing pressure from public policies and the market in Europe. The "Farm to Fork" strategy sets targets for 2030, including a 50% reduction in the overall use and risk of chemical pesticides and at least a 50% reduction in nutrient losses, while also reducing fertilizer use by at least 20% (European Commission, 2020, pp. 7-8). These goals imply a change in management practices for crop farms. Better control of application rates, timing, and treatment outcomes is required – hence better data and a more efficient decision-making process.

It should also be noted that the digitalization of agriculture is not developing evenly. JRC research indicates that although 93% of EU farms use basic digital tools (a computer, the internet, general software), technologies directly related to crop production are implemented much less frequently and to a highly varied extent (from a few to several dozen percent) (Cardona et al., 2025, p. 5). In practice, farmers rarely implement a full package of solutions; more often, they select those that most quickly streamline decision-making and costs.

In summary, Society 5.0 in agriculture makes sense when technologies and data genuinely help farmers run their farms in a way that is simultaneously economically viable, less burdensome to the environment, and more organizationally stable (Breque et al., 2021, p. 9; Whelan, 2007, p. 2).

In this article, it is assumed that the meaning of Society 5.0 in a crop farm is expressed not in the number of technologies used, but in whether or not technology improves decision quality and facilitates the integration of the three pillars of sustainability. The aim of the article is therefore to show how the ideas of Society 5.0 can be translated into the everyday management of a crop farm and what real benefits and limitations accompany such a transformation in the conditions of a farm located in the Kujawsko-pomorskie Province of Poland.

2. Methodology of the case study

The article is based on a case study of a single anonymous crop farm located in the Kujawsko-pomorskie Province of Poland. The empirical material covered data from the 2024/2025 farming year, including crop structure, yield levels, and basic records of purchases and use of selected production inputs (e.g. mineral fertilizers, plant protection products, fuel/energy). Quantitative analysis of operational data was complemented by a structured interview with the farm owner, addressing farm characteristics, the level of digitalization, decision-making processes, and the assessment of benefits and barriers associated with solutions linked to Agriculture 5.0.The interpretation of results was embedded in a review of current literature on Society 5.0 and Industry 5.0, adopting a "human-centred" perspective in which digital technologies are intended to support farmers in making faster and more accurate decisions, improving work organization, and reducing losses and risks on the farm, rather than increasing administrative burdens (Cabinet Office, Government of Japan, 2021, p. 11).

The selection of measures was purposeful. It was assumed that the indicators analyzed should be based on data that can be collected within the framework of day-to-day farm operations and should primarily reflect the actual effects of actions undertaken, rather than declarations or planning assumptions.

To ensure the transparency and comparability of results, the following principles were adopted:

- mineral nitrogen use (kg N/ha) was calculated as the total amount of nitrogen resulting from mineral fertilizers applied during a given season, related to the area of arable land; the calculations were based on fertilization records and purchase documents, with adjustments for changes in stock levels where applicable,
- the use of plant protection products was expressed as kilograms of active substance per hectare (kg a.s./ha), based on treatment records (product, dose, area); in the case of multi-component products, active substances were summed according to the product label,
- the costs of mineral fertilizers and plant protection products (PLN/ha) were calculated as purchase costs attributed to the analyzed season and related to the cultivated area; only variable costs associated with the purchase of production means were included in the analysis,
- the costs of digital solutions (e.g. system subscriptions, GNSS services) were treated as organizational and technical costs and analyzed qualitatively, rather than as elements of variable production costs.

The reference point for changes in the use of production inputs and costs was the values derived from farm records from the period immediately preceding the analyzed season, which made it possible to assess the direction and scale of changes while maintaining interpretative caution.

At the same time, it was assumed that the observed effects are multi-factorial in nature, and their interpretation focuses primarily on mechanisms for reducing operational and organizational losses (e.g. overlapping passes, repeated treatments, delayed decisions), rather than on fully isolating the impact of digital technologies from other production-related conditions.

3. Characteristics of the studied farm

The studied crop farm operates on 112 ha of agricultural land. It is located in the central part of the Kujawsko-pomorskie Province region, in an area with moderately favourable climatic conditions for crop production and a predominance of medium and good-quality soils typical of the Kujawy region. According to the soil valuation classification, soils of classes IIIa, IIIb, and IVa dominate, which supports intensive, market-oriented crop production while also implying sensitivity to agrotechnical errors and excessive chemical pressure.

The terrain is predominantly flat or slightly undulating, which facilitates the mechanization of field operations. At the same time, fields of irregular shapes and varying sizes occur, which has significant implications for the organization of machinery passes and the risk of overlapping treatments.

The crop structure (Figure 1) was designed to combine crop rotation stability with market flexibility. In the 2024/2025 season, winter wheat dominated with 42 ha (37.5%), followed by winter rapeseed with 18 ha (16.1%) and grain maize with 20 ha (17.9%). These were complemented by sugar beet—12 ha (10.7%), barley—10 ha (8.9%), legumes (pea)—6 ha (5.4%), and catch crops/technological fallow—4 ha (3.6%). Such a structure reduces the risk of monoculture and allows fieldwork and costs to be spread over time, which in practice enhances the farm's organizational stability.

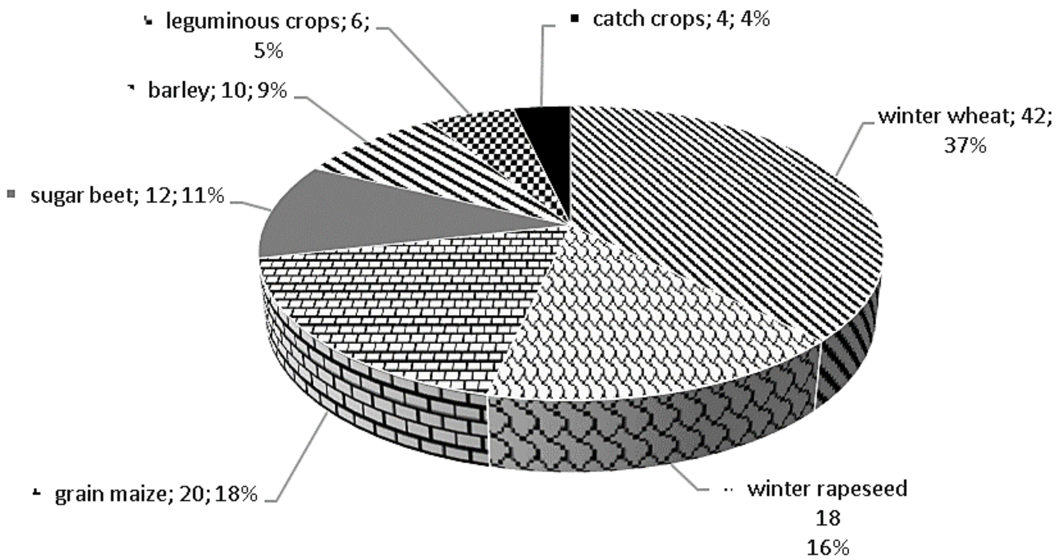

Figure 1. Crop structure in the studied farm [ha].

Source: own study.

The farm has a family character and is managed by the owner together with family members – his wife and son. The owner acts as the main decision-maker, machinery operator, and the person responsible for documentation and contacts with external institutions.

During periods of the highest intensity of fieldwork (sowing and harvesting), the farm seasonally employs two additional workers, with no permanent employment, however.

The total number of people involved in the farm's day-to-day operations over the year is three (the owner, his wife and son), and during peak periods this workforce is supplemented by two seasonal workers. This results in a high concentration of decision-making and operational responsibilities in the hands of the owner. This kind of organizational structure increases the importance of tools that support planning, coordination of work, and the reduction of errors arising from time pressure.

The farm's machinery park is typical for medium-sized crop farms in the region and includes, among others, agricultural tractors of varying power, a field sprayer, a mineral fertilizer spreader, seed drills, and tillage equipment. Some of the machines are equipped with terminals enabling GNSS-based parallel guidance and automatic section control, which constitute an important foundation for the further digitalization of production processes.

Work organization on the farm can be described by strong seasonality. During periods of intensive fieldwork decisions must be made quickly, often under conditions of incomplete information and weather pressure. In such circumstances, the lack of well-organized treatment records and an up-to-date picture of field conditions increases the risk of repeated operations, delays, and operational losses. For this reason, the farm represents a good example of a unit in which digitalization is not an end in itself, but a response to organizational and time constraints.

In this case study, the key issue was not so much what to cultivate, but how to make decisions under pressure to reduce chemical use and meet growing documentation requirements. It is precisely in this context that digitalization began to play a structuring role – not as a one-off investment, but as a gradual process of building better information about fields, treatments, and costs.

4. Digitalization in the spirit of Society 5.0 – from data to decisions in the field

In the studied farm, digitalization was not implemented as a "big project," but rather as a series of practical steps introduced gradually where the lack of data most strongly hindered management and generated the greatest losses (time-related, cost-related, or organizational). This approach was consistent with the logic of Society 5.0, in which technology plays a role that supports people rather than imposing rigid organizational solutions.

The digitalization process began with organizing information that had previously existed in the form of scattered notes, loose sheets of paper, calendar entries, and the farm owner's memory regarding when and where agrotechnical operations had been carried out. Earlier, this information was often reconstructed after the season had ended, which increased the risk of errors and inaccuracies, especially in situations involving inspections, planning for the next season, or comparing costs between fields.

At this stage, an FMIS (Farm Management Information System) was implemented – an information system for farm management designed to collect, process, store, and share data needed to conduct ongoing field operations (Tummers, Kassahun, Tekinerdogan, 2019, pp. 1-2). In practice, the FMIS became the place where the farm began to consolidate information about fields and operations in chronological order. In other words, it served as a central repository of operational data rather than merely an electronic equivalent of a notebook.

First, a field database was created, including plot boundaries, field names, areas, and the crops grown in a given season. Next, templates for the most frequently performed operations were prepared (e.g. pre-sowing fertilization, herbicide and fungicide protection), which reduced the need to enter data from scratch each time. During the season, only variable elements were updated: the date of the operation, the applied rate, weather conditions, and the person performing the work.

A key organizational change was shifting the moment of record-keeping from the "after the season" stage to "at work" stage. Records of fertilization, crop protection, and passes began to be created immediately after an operation was performed, most often using a mobile device. As a result, the farm stopped reconstructing the season's history from memory and instead began building it continuously – field by field and day by day.

Only on this basis did the FMIS start to function as a decision-support tool rather than solely a record-keeping tool. The farmer could quickly check which operations had already been carried out, on which fields, and at what rates, which reduced the risk of repetition and enabled comparisons of input use between plots. The system was also used for planning the next season and assessing the effectiveness of implemented solutions.

Within the logic of Society 5.0, this way of implementing technology is fundamental, because technology should facilitate decision-making and relieve farmers of the burden of memorization and bureaucratic reconstruction of data, rather than creating an additional layer of administrative duties (Cabinet Office, Government of Japan, 2021, p. 11). At the same time, the subject literature emphasizes that modern FMIS solutions are expected to support managerial decisions and organize farm business processes precisely in order to reduce costs and facilitate compliance with quality requirements and standards (Tummers et al., 2019, p. 2).

The second stage of digitalization focused on reducing losses resulting from field geometry – primarily overlapping passes, repeated treatments on headlands, and unnecessary traffic lanes on irregularly shaped plots. For this purpose, the farm introduced GNSS (Global Navigation Satellite System) in key field operations such as tillage, sowing, and spraying. The machinery driving route ceased to depend solely on the operator's experience and visible wheel tracks and, instead, began to follow guidance lines displayed on the in-cab terminal screen. Meanwhile, where most justified in terms of cost and environmental impact, automatic sprayer section control was implemented. This enabled individual boom sections to be switched on and off depending on the area of the field that had actually been covered. In practice, this eliminated double application of spray solution on headlands and field wedges.

Studies indicate that automatic section control can reduce overlap on average by about 9% for sprayers and about 6% for seeders, although the magnitude of benefits depends on field size and shape (Shockley et al., 2012, pp. 413-414). In the studied farm, the effect was less spectacular, but still sufficiently important to be reflected in the records of plant protection product use. The key was not achieving the maximum possible reduction, but the systematic elimination of operational errors.

The third area of digitalization involved better matching of fertilization and crop protection to field conditions, without assuming full automation of the process. The farm began combining simple data – such as the history of operations, field structure, and crop observations – with weather information and a short-term work plan. This enabled the more accurate selection of treatment windows and a decrease in situations where operations were repeated due to haste or an incorrect assessment of conditions.

This approach aligns with the assumptions of Society 5.0, in which digital technologies are meant to support people in making decisions at the right time, rather than replacing their knowledge and experience. Thus, in the studied farm, the key was not increasing the number of technologies, but minimizing losses resulting from repeated operations, overlapping passes, and decisions made too late or on the basis of incomplete information.

5. Results – measurable effects from the perspective of the three pillars of sustainability

The assessment of the effects of the implemented digital solutions was conducted from the perspective of the three pillars of sustainable development: environmental, economic, and socio-organizational. It was assumed that the key importance does not lie in individual technologies, but in the combined effect of data organization, improved decision-making processes, and the reduction of operational losses in the crop farm.

5.1. Environmental and resource-related effects

In the studied farm, the greatest environmental potential emerged in areas where losses were difficult to capture: excessive application rates, repeated treatments on headlands, and operations carried out "just in case" due to a lack of complete information. The reduction of pressure on resources did not result from a radical change in cultivation technology, but rather from greater data discipline and improved work organization.

Table 1.
Selected indicators before and after the implementation of digital solutions

Indicator	Before implementation	After implementation	Difference
Mineral nitrogen use (kg N/ha)	160	145	-9.4%
Plant protection product use (kg active substance/ha)	2.9	2.6	-10.3%

Source: author's own study.

In the analyzed year, the farm recorded a decrease in mineral nitrogen use (calculated per arable land area) from 160 kg N/ha to 145 kg N/ha, which represents a reduction of 15 kg N/ha (–9.4%). This change resulted from several minor adjustments: better temporal planning of application rates, reduced overlap of passes, and more accurate selection of treatment timing in relation to weather conditions and crop growth stages. A similar trend was observed in the use of plant protection products. The average active substance use for major crops declined from 2.9 kg a.s./ha to 2.6 kg a.s./ha (–0.3 kg; –10.3%). This reduction was mainly due to fewer repeated treatments on headlands and field edges, as well as more consistent timing of applications.

The obtained results are directionally consistent with the objectives of the "Farm to Fork" strategy, which aims, among others, to reduce nutrient losses and decrease the use of fertilizers and pesticides. At the same time, they fall within the range of effects reported in synthetic studies on precision agriculture, which indicate improvements in nitrogen use efficiency and reductions in pesticide application. In the studied farm, these changes were achieved without a declared decrease in production levels.

5.2. Economic effects: variable costs and process control

In a crop farm, the "economics of sustainability" becomes evident when reducing inputs does not lead to yield losses or delays in field operations. A key factor was the integration of treatment records with on-field control of their execution. When the farmer can see which operations were actually carried out and where, it is easier to maintain discipline in application rates and eliminate unnecessary repetitions.

Table 2.
Selected indicators before and after the implementation of digital solutions

Indicator	Before implementation	After implementation	Difference
Costs of mineral fertilizers (PLN/ha)	1800	1520	-280
Costs of plant protection products (PLN/ha)	900	780	-120

Source: author's own study.

Farm records show that the costs of mineral fertilizers per hectare decreased by approximately PLN 280/ha (–5.8%), while the costs of plant protection products decreased by about PLN 120/ha (–7.5%). The cost reduction did not take the form of a one-off "technological gain," but rather resulted from the systematic limitation of operational losses, such as duplicated passes, corrective treatments, or the purchase of production inputs at less favourable price moments.

At the same time, it should be emphasized that in the studied farm the implementation of digital tools was associated with additional organizational and technical costs, including software, maintenance of GNSS solutions, and the time required for implementation and learning. From a managerial perspective, however, it was important that these costs were predictable and could be planned, in contrast to earlier operational inefficiencies that generated losses difficult to estimate during the season. In this sense, the farm improved not only its cost level but also the degree of control over the production process, which is particularly important under conditions of weather variability and time pressure characteristic of crop production.

5.3. Social and organizational effects: the human at the center of the process

The social effects of the implemented solutions are not easy to capture using a single indicator; however, they are clearly reflected in work organization and decision-making processes. Within the logic of Society 5.0, technology should improve the quality of work and decision security, rather than merely increase production efficiency.

In the studied farm, the most noticeable effect of technology implementation was a reduction in time pressure and a shortening of the time spent reconstructing documentation after the end of the season. Keeping records on an ongoing basis enabled calmer planning of operations and earlier responses to deviations from the plan. Decisions ceased to be made in a "last-minute" mode and became more repeatable and less cognitively burdensome.

Organizing data related to fertilization and crop protection and providing a clear picture of field conditions within a single system reduced information chaos and limited the risk of errors resulting from reliance solely on memory, scattered notes, or photos stored on a phone. As a result, technology did not "produce yield" itself, but strengthened the farmer's agency by facilitating planning, monitoring the execution of operations, and maintaining consistent documentation required by the market and regulations.

These effects align with the human-centred character of Society 5.0, in which digitalization is intended to support people in decision-making and work organization, thus contributing to greater predictability of actions and a reduction in the time-related and psychological costs of farm management.

6. Barriers and risks: why not everything can be "automated"

The analysis of the case study indicates that despite noticeable environmental, economic, and organizational benefits, the digitalization process in a crop farm encounters significant barriers and risks that limit both the pace and scope of implementing more advanced solutions.

These barriers do not stem solely from the availability of technology, but are largely the result of integration, competency, and institutional challenges characteristic of medium-sized crop farms.

6.1. Technical and integration barriers

One of the key barriers identified in the studied farm was the low level of interoperability between the digital solutions in use. Data on treatment records collected in the FMIS, files generated by GNSS terminals, and machine work reports largely functioned as separate "information islands." Obtaining a coherent picture of the production season (e.g. linking actual passes with the applied rate, cost, and treatment effect on a specific field) required manual data export, format conversion, unification of field and operation names, and mapping the same fields across different systems. In practice, this meant that part of the potential benefits of digitalization was limited not by a lack of technology, but by the time-consuming nature of data organization and the absence of uniform data exchange standards. This phenomenon is consistent with findings from studies conducted at the European Union level, which indicate that farm data are still often collected and processed in a fragmented manner, increasing the administrative burden on farmers and limiting their analytical use (Tur Cardona et al., 2025, pp. 4-6).

An additional technical constraint was the quality of ICT infrastructure. Even the most advanced applications lose their usefulness in the absence of stable internet access. Limited connectivity in some locations hindered real-time data synchronization and encouraged the selection of offline solutions, at the expense of systems requiring constant connectivity, updates, and technical support. Within the European Union, 85% of surveyed farms declare adequate internet coverage, yet 15% still report insufficient connectivity (Tur Cardona et al., 2025, p. 6). Under such conditions, farmers are more likely to choose proven and easy-to-use solutions, even if their integration and analytical potential is limited.

6.2. Organizational and competency barriers

The second important group of barriers included organizational and competency constraints. In a farm where most decision-making, operational, and administrative responsibilities rest with a single person, any new technology must be not only functional but also easy to implement and operate under conditions of time pressure and strong seasonality of work.

The process of learning to use digital systems, configuring devices, and interpreting generated data involved additional time costs that were not always offset by immediate economic benefits. In practice, this favoured the selective adoption of only those tools that most quickly organized the decision-making process and documentation, as well as caution toward more advanced solutions requiring greater organizational commitment.

An important factor was also the perceived risk of error. When systems are seen as overly complex or unintuitive, farmers fear losing control over the production process and prefer solutions that leave decision-making in human hands. In this sense, full automation is not always perceived as a desirable direction of development, especially in medium-sized crop farms.

6.3. Institutional risks and data governance

The third group of barriers consists of risks related to data governance and the relationship between farmers and technology providers. Data generated by machines, sensors, and information systems are gaining increasing economic value, as they directly influence production decisions, costs, and farm performance. At the same time, farmers often lack full certainty regarding the rules of access to, portability of, and further use of these data.

The risk of dependence on a single technology provider (vendor lock-in) limits the willingness to integrate systems and invest in solutions that may prove to be technologically closed. In the studied farm, these concerns related primarily to long-term access to historical data and the possibility of using them in other systems in the future.

In this context, the Data Act regulation is of particular importance. It entered into force on 11 January 2024 and will apply from 12 September 2025. This act regulates, among other things, the rules of access to data generated by connected products and the conditions for data sharing (Regulation (EU) 2023/2854, 2023, recital 117, p. 30). From the perspective of a farm, this regulation represents a potential factor in building trust in investments in digital technologies over the long term, as it strengthens the position of data users versus technology providers (Regulation (EU) 2023/2854).

However, it should be emphasized that legal regulation alone does not guarantee practical system interoperability or easy use of data in everyday farm management. If digital solutions are to function over many years, farmers must have a sense of maintaining control over their data. Whether such control will be possible in practice will ultimately depend on the adopted technical standards and applied business models.

6.4. Limits of automation in a crop farm

The case study shows that not all processes in a crop farm can be effectively automated. Decisions concerning the timing of treatments, responses to changing weather conditions, or the interpretation of crop status still require the farmer's knowledge and experience. Digitalization can support these decisions by providing better information, but it does not replace human decision-making responsibility.

In the studied farm, the most effective solutions were those that reduced operational errors and organized the work process, rather than those aiming at full automation. Thus, the boundary for technology implementation was not the level of its sophistication, but its ability to genuinely support the decision-making process without increasing organizational complexity or operational risk.

7. Conclusions

The conducted case study shows that sustainable management of a crop farm in the spirit of Society 5.0 does not require full automation or the implementation of comprehensive, costly technological systems. What matters most is a logical sequence of actions in which digitalization serves as a tool that structures the decision-making process, reduces operational losses, and strengthens control over the course of production.

In the studied farm, the starting point proved to be the organization of operational data and treatment records. Only the creation of a coherent, up-to-date information base on fields, passes, and applied rates enabled further organizational improvements. Shifting documentation from the "after the season" stage to the "at work" stage was important not only for data quality, but also for improving decision security and reducing time pressure.

On this foundation, it became possible to effectively reduce field-level operational losses, such as overlapping passes, repeated treatments on headlands, or unintended double applications of inputs. The use of GNSS parallel guidance and automatic section control did not change the biology of production, but it eliminated operational errors that, in practice, generate a significant share of excess costs and environmental pressure.

The achieved environmental effects – reduced use of mineral nitrogen and plant protection products – were not the result of a radical change in cultivation technology, but rather a consequence of better work organization and more timely, better-targeted decisions. Similarly, in economic terms, the key was the reduction of hidden cost losses resulting from repetitions and inefficient operations, rather than a one-off increase in production efficiency.

An important outcome of the implemented solutions were also the social and organizational effects. Digitalization contributed to a reduced administrative burden, greater predictability of seasonal work, and less information chaos. In this sense, technology did not replace the farmer but strengthened the farmer's agency, fitting the human-centred character of Society 5.0.

At the same time, the case study reveals clear barriers to further digitalization, which are related primarily to data integration, user competencies, and the risk of dependence on closed technological ecosystems. This means that the further development of digital agriculture should not focus exclusively on delivering more tools, but rather on improving interoperability, ease of use, and building trust in data governance principles.

The conclusions drawn from the study are application-oriented and should not be treated as representative of the entire agricultural sector. They do show, however, that even in a single medium-sized crop farm, it is possible to gradually strengthen sustainability through the conscious use of data and decision-support technologies. The most rational development path appears to be an incremental approach, starting with organizing information and controlling the process, and only subsequently reaching for more advanced technical solutions.

In this perspective, Society 5.0 in agriculture does not mean "more technology", but a better use of available tools in a way that simultaneously strengthens economic efficiency, reduces environmental pressure, and improves the working conditions of people in crop farming.

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