Selective Management in Sustainable Agri-Food Systems

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***Abstract* – A sustainable agri-food system is designed to ensure food security and nutrition by establishing the economic, social, and environmental foundations required for food security. This article delves into the concept of selective management within sustainable agri-food systems for livelihood development. To systematically categorize and identify contemporary directions of scientific research on this topic, a descriptive analysis was conducted using sources from the Scopus scient metric database. The article proposes examining agri-food system functionality through the lens of sustainable development goals. Additionally, the article underscores the transformative influence of digitalization on these processes. The study highlights the challenges and prospects brought about by digital technologies in agribusiness, while stressing the necessity of tackling ethical, social, and environmental considerations. It calls for the formulation of policies and regulations to ensure the responsible use of these technologies.**

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1. Introduction

The agri-food system represents an intricate network of interconnected elements responsible for the production, processing, distribution, and consumption of agricultural products. Encompassing the entire spectrum of food production, it coversactivities such as plant and animal cultivation, harvesting, processing, storage, transportation, distribution, and final consumption [1], [2]. Additionally, the agri-food system encompasses the infrastructure, technologies, policies, and regulatory mechanisms that significantly shape its operation.

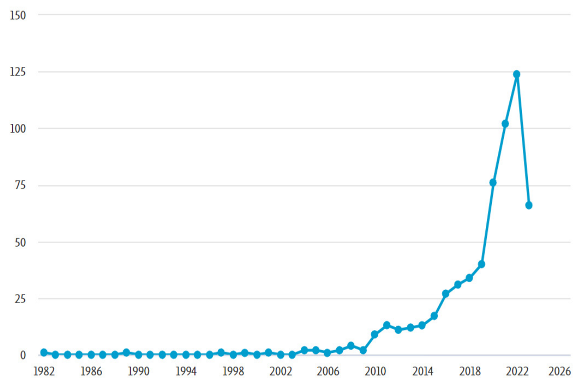
Structural transformations within the agri-food system are driven by diverse processes and factors. These encompass alterations in production techniques, shifts in land and resource utilization, and changes in supply and consumption patterns. Multiple influences can trigger these structural adjustments, including climate variations, demographic shifts, economic and political conditions, technological advancements, and evolving consumer behaviors [3], [4], [5]. Such modifications can yield both positive and negative repercussions for the agri-food system, underscoring the necessity for them while formulating agricultural and food security policies and strategies [6], [7], [8], [9].

Notably, structural transformations within the agri-food system are often instigated by changes in other systems. For instance, policies promoting biofuel adoption within the energy sector can exert significant impacts on the food system and vice versa.

To mitigate such consequences, the pursuit of a sustainable agri-food system has gained prominence [10], [11], [12], [13]. A sustainable agri-food system encompasses efficient and sustainable agricultural production, conservation of natural resources and biodiversity, and consistent, accessible food availability [14], [15]. Realizing such a system mandates considerations of environmental, economic, and social dimensions, advocating for resource-efficient practices, the integration of pioneering technologies, the fostering of agricultural enterprises, and the enhancement of societal well-being [16], [17].

To comprehensively organize the conceptual framework and discern contemporary trajectories of scientific inquiry into this domain, a descriptive analysis leveraging the Scopus scientometric database was employed. The analysis highlights a pronounced upswing in scholarly attention directed towards cultivating a sustainable agri-food system.

In the Scopus database, the keywords "agri-food system" and "sustainable development" yield a cumulative of 593 documents spanning from 1982 to 2023. This trend is visualized in Figure 1.



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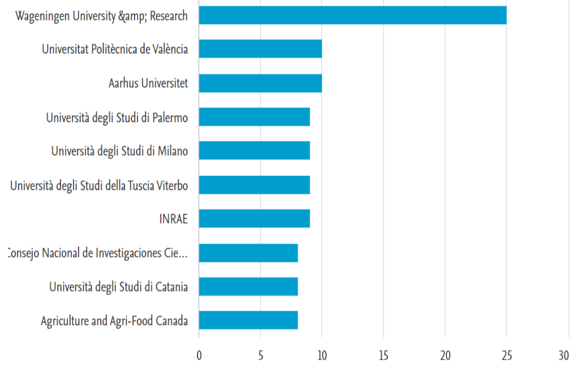

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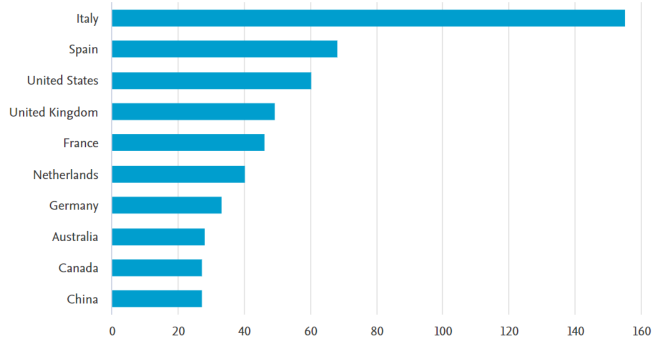

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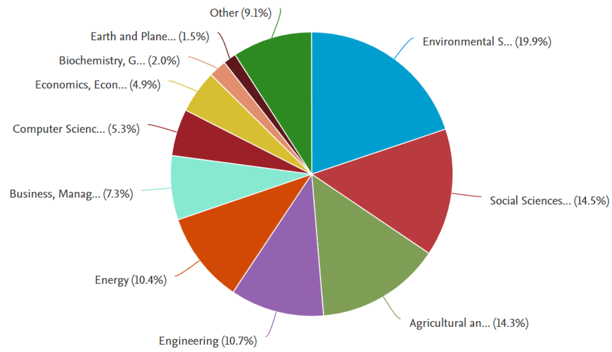

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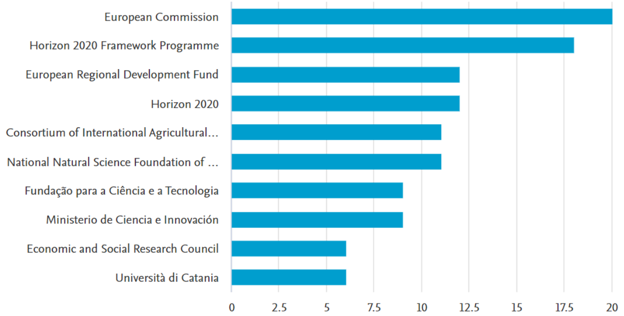

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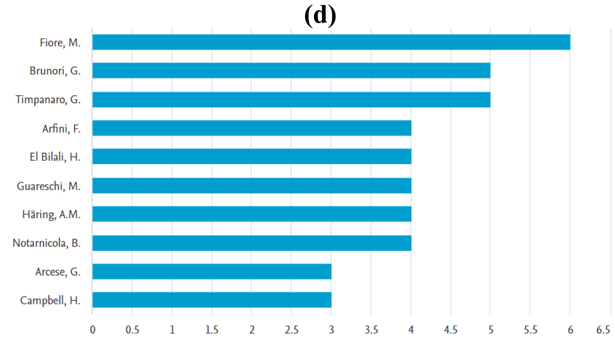

(f)

(a) number of documents by year, (b) documents by, (c) documents by, (d) documents by field of knowledge, (e) documents on publication-sponsoring entities, (f) documents on authors publishing research results

Figure 1. Analytical study of keyword search - data from the Scopus Scientometric database

An analytical study of the keywords "agri-food system" and "sustainable development" reveals a significant surge in scientific interest, particularly evident since 2019 (attributed to the influence of COVID-19). Notably, this interest reached its zenith in 2022 (a). Predominantly, researchers emanate from countries such as Italy, Spain, the United States, the United Kingdom, (c), reflecting corresponding research institutions in these regions (b). The pursuit of sustainable development within the agri-food system encompasses an extensive array of fields of knowledge. This spans environmental science (20%), social sciences (14.5%), agricultural and biological sciences (14.3%), engineering (10.7%), energy (10.4%), business, management, and accounting (7.3%), among others (d).

The European Green Deal (Fetting, 2020) represents a comprehensive roadmap delineating measures to transform the European Union into a resilient, sustainable, and competitive economy. This initiative encompasses the realization of a climate-neutral Europe by 2050, converting environmental and climate challenges into prospects across all sectors and policies of the EU, and facilitating an equitable and comprehensive green transition. The European Green Deal Action Plan encompasses nine key areas of implementation: (1) climate; (2) energy; (3) circular economy industrial strategy; (4) sustainable and intelligent mobility; (5) eco-friendly agricultural policy; (6) biodiversity conservation; (7) zero pollution; (8) financial instruments; (9) the EU's global leadership. Consequently, the agri-food transition necessitates preliminary scientific inquiry.

As a result, funding for research pertaining to the sustainable agri-food system primarily derives from international funds, including the European Commission, Horizon 2020 Framework Program, European Regional Development Fund, Horizon 2020, and Consortium of International Agricultural Research Centers, alongside grants and more.

With the advent of digitalization in agribusiness, an array of novel technologies and tools has surfaced, harboring the potential to revolutionize this realm [18]. The discourse surrounding innovative strides in biotechnology and digitalization, currently harnessed to enhance reproductive processes within the agri-food system, as well as the ensuing challenges and prospects, has been invigorated [19].

The subject of selective management pertaining to reproductive processes within agri-food systems assumes paramount significance and pertinence within the food market, owing to several cogent reasons. Primarily, the food market is perpetually evolving, with consumers exhibiting heightened concerns regarding the safety and quality of the comestibles they partake in.

Through the refinement of animal and plant breeding, the food industry can furnish healthier, safer, and more nutritionally endowed products that resonate with consumer expectations. Moreover, the application of biotechnology and digitalization in the selective governance of reproduction processes holds the potential to yield augmented efficiency, productivity, and profitability within the agri-food system [20].

It carries the capacity to amplify crop yields, mitigate environmental footprints, and ensure a robust food supply in the face of a burgeoning global populace [21], [22].

The selective management of reproduction processes within food markets and agri-food systems, set against the backdrop of agribusiness digitalization, constitutes a swiftly progressing field with profound ramifications for food production, sustainable development, and market dynamics [23], [24].

Breeding stands as a conventional methodology for enhancing desirable traits in both crops and animals. Studies have substantiated the efficacy of breeding in augmenting yields, bolstering disease resistance, and enhancing the nutritional quality of diverse food crops and animal species [25], [26]. However, the limitations inherent to traditional breeding, encompassing protracted breeding cycles and intricate interplays between traits, have spurred an exploration of advanced genetic methodologies [27].

Research contributions by multiple scholars delve into an array of facets associated with the selective control of reproductive processes, the digitalization of agribusiness, and the utilization of transformative technologies. These technologies encompass genomics, precision agriculture, the Internet of Things (IoT), blockchain, and statistical methodologies within the agricultural domain [28], [29], [30], [31].

The collated literature underscores significant strides and the potential of genomic tools, genome engineering, precision agriculture technologies, and statistical methodologies in refining animal breeding, crop enhancement, and agricultural practices, particularly amid the backdrop of climate fluctuations and food security imperatives. The amalgamation of these cutting-edge technologies portends substantial promise for fostering sustainable and efficient agricultural systems in the impending future [32], [33].

Articles authored by various researchers encompass a diverse array of subjects spanning the realm of agriculture and technology.

These subjects include the IoT in agriculture, blockchain's role in the food sector, the quantification of yield losses in rice due to pests, the ramifications of genetically engineered crops, consumer perspectives on genetically modified foods, the economic dimensions of gene drives, comparative approaches to GMO regulation, case studies spotlighting specific genetically modified crops, public outlooks on agricultural biotechnologies, and the economic and environmental impacts of genetically modified crops [34], [35].

The landscape of genetic engineering and gene editing techniques has undergone a revolutionary transformation, particularly within the domain of selective reproductive process control in agribusiness. These methodologies offer the capacity for precise manipulation of an organism's genetic composition, affording the introduction of coveted traits or the suppression of undesirable attributes. A plethora of studies underscore the successful implementation of genetic engineering and gene editing in heightening crop productivity, bolstering disease resilience, and amplifying nutritional. Within animal production, genetic engineering finds application in enhancing characteristics such as milk production, growth velocity, and disease resilience [36], [37].

The digitalization of agribusiness has engendered substantial strides in the realms of precision agriculture, big data analytics, IoT, and blockchain technologies. Precision agriculture harnesses sensors, drones, and satellite imagery to meticulously oversee and manage agricultural processes with precision and efficacy [38], [39], [40]. The realm of big data analytics empowers the evaluation of extensive datasets to extrapolate insights, optimize production processes, and prognosticate market tendencies. IoT devices facilitate real-time monitoring of production systems, thereby facilitating timely interventions and resource optimization. Concurrently, blockchain technology proffers transparency and traceability within supply chains, and the legitimacy and quality of agricultural products [41], [42].

Numerous investigations have delved into the convergence of selective control methodologies with digital technologies within agribusiness. The amalgamation of precision agriculture and selective breeding has promising outcomes, manifesting in the refinement of breeding schemes, the enhancement of crop attributes, and the elevation of production efficiency. The deployment of big data analytics and AI algorithms has empowered more informed decision-making within breeding initiatives by discerning genetic patterns, prognosticating phenotypic traits, and streamlining selection procedures.

The integration of IoT devices has facilitated the real-time monitoring of reproduction processes, thus enabling timely identification of health concerns, curbing wastage, and optimizing resource utilization. Additionally, the adoption of blockchain technology ensures transparency, traceability, and bolstered confidence in breeding endeavors, thereby fostering enhanced consumer trust [43].

In its entirety, the literature review underscores the pivotal import of selective control over reproduction processes within food markets and agri-food systems. Moreover, it accentuates the potential inherent in amalgamating digital technologies to refine breeding initiatives, enhance traits, and ensure traceability [44], [45], [46]. Nevertheless, it also concedes the ethical, social, and environmental apprehensions tethered to these technologies, underscoring the imperative of prudent implementation, stakeholder engagement, and regulatory frameworks.

Through an exhaustive analysis of the array of keywords, discernible key themes and patterns associated with scientific publications concerning sustainable agriculture unearthed:

- Sustainability and Sustainable Agro-Industrial Systems: This thematic umbrella encompasses research endeavors geared safeguarding the sustainable progression of agro-industrial systems and environmental preservation. Noteworthy terms underpinning this theme encompass "sustainability," "environmental," and "resource use."
- Interconnections Amidst Diverse Themes and Authors: Notable interrelations have been detected amidst "agrarian heritage," "agroeconomics," and "local agro-industrial systems."
- Emerging Areas and Trends: Novel thematic domains and trends have surfaced, encompassing subjects such as "digital agriculture," "innovation within agricultural research," and "food security."
- Stakeholders and Their Roles: Prominent researchers and influential figures within the realm of sustainable agriculture have been identified. Noteworthy stakeholders encompass "CGIAR," "farmers' organizations," and "agricultural development policy."

The research studies scrutinized within this article wield the potential to discern gaps in research through a more rigorous analytical lens. For practitioners, it furnishes a concise overview of the prevailing dynamics within the economy, the agricultural sector, and agribusiness. Serving as an interdisciplinary review, this research probes the primary prospects and capabilities underpinning sustainable agri-food systems to foster and perpetuate sustainable functionality.

2. Methodology

The foundational methodological framework for elucidating the factors governing the evolution of sustainable agri-food systems is rooted in the paradigm of sustainable development. The underpinnings of agri-food policy stem from the sustainable development goals (SDGs), intricately interwoven with the objectives and benchmarks stipulated by the SDGs themselves [47].

The study is underpinned by a blend of comprehensive scientific methodologies and specialized research techniques.

Paramount among these are systematic literature reviews encompassing top-tier works archived within the Web of Science and Scopus databases, interviews, scrutiny of documentation originating from the European Union and Ukraine, the application of mathematical modeling and prognostication techniques.

Illustrating an analytical exploration, the study presents an in-depth investigation of 593 scientific publications meticulously cataloged within Scopus. This exploration is predicated upon keyword analyses, as depicted in Figure 2.

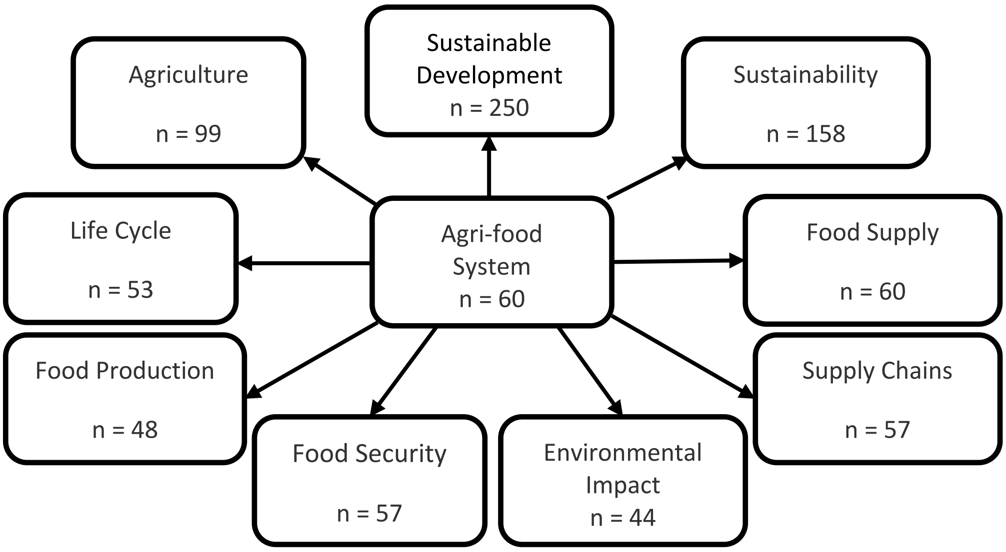

Figure 2. Categorization of the of the Scopus

When scrutinizing the frequency of keywords within the scientific publications, the paramount category within the agri-food system (n = 60) emerges as sustainable development (n = 250), underscored by the pursuit of fostering the appropriate state of agriculture (n = 99) through the lens of sustainability (n = 158). The agri-food system represents an intricate nexus of entities and operations entwined in the spectrum of food product production, processing, distribution, and consumption.

It spans a diverse array of stakeholders, encompassing farmers, producers, distributors, retailers, and consumers.

The quintessential facets of the agri-food system are inexorably tied to the quality and safety of food products. These facets are contingent upon a multitude of factors, genetics, environmental influences, and management methodologies.

This intricate agri-food system can be comprehensively divided into four overarching categories, as illustrated in Figure 3.

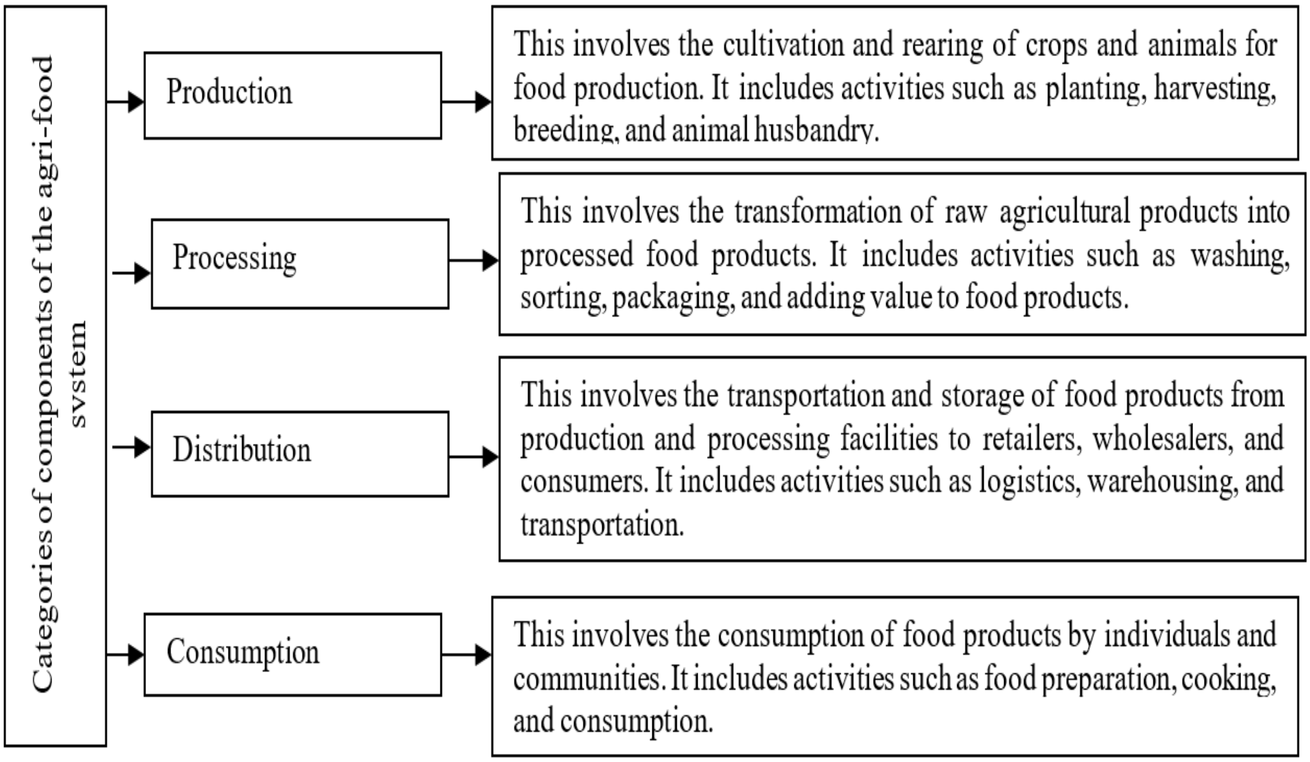

Figure 3. Categories of components within the agri-food system

The components constituting the agri-food system are intricately interwoven and interdependent, their dynamics shaped by a multitude of factors ranging from climatic conditions and environmental nuances to governmental policies, consumer preferences, and technological progress. The efficacy and potency of the agri-food system hinge upon the seamless integration and adept management of these components, ultimately ensuring a secure, healthful, and sustainable food provision for all.

In alignment with the primary objectives of sustainable development within the agri-food system, the following aspects emerge as pivotal:

– Ensuring Food Security (Food Security, n = 57): This encompasses the provision of quality, accessible food production (Food Production, n = 48) for the populace.

– Conservation of Natural Resources: Attenuating the adverse impact of agricultural pursuits on vital elements such as soils, water resources, and biodiversity (Environmental Impact, n = 44).

– Economic: This entails ensuring the profitability of agricultural enterprises, fostering the evolution of market chains, and bolstering infrastructure (Supply Chains, n = 57; Food Supply, n = 60).

– Fostering Sustainable Development within Rural Areas; This involves the preservation and advancement of agricultural infrastructure, championing small-scale farms, and nurturing agricultural entrepreneurship (Life Cycle, n = 53).

The schematic depiction of the research framework is presented in Figure 4.

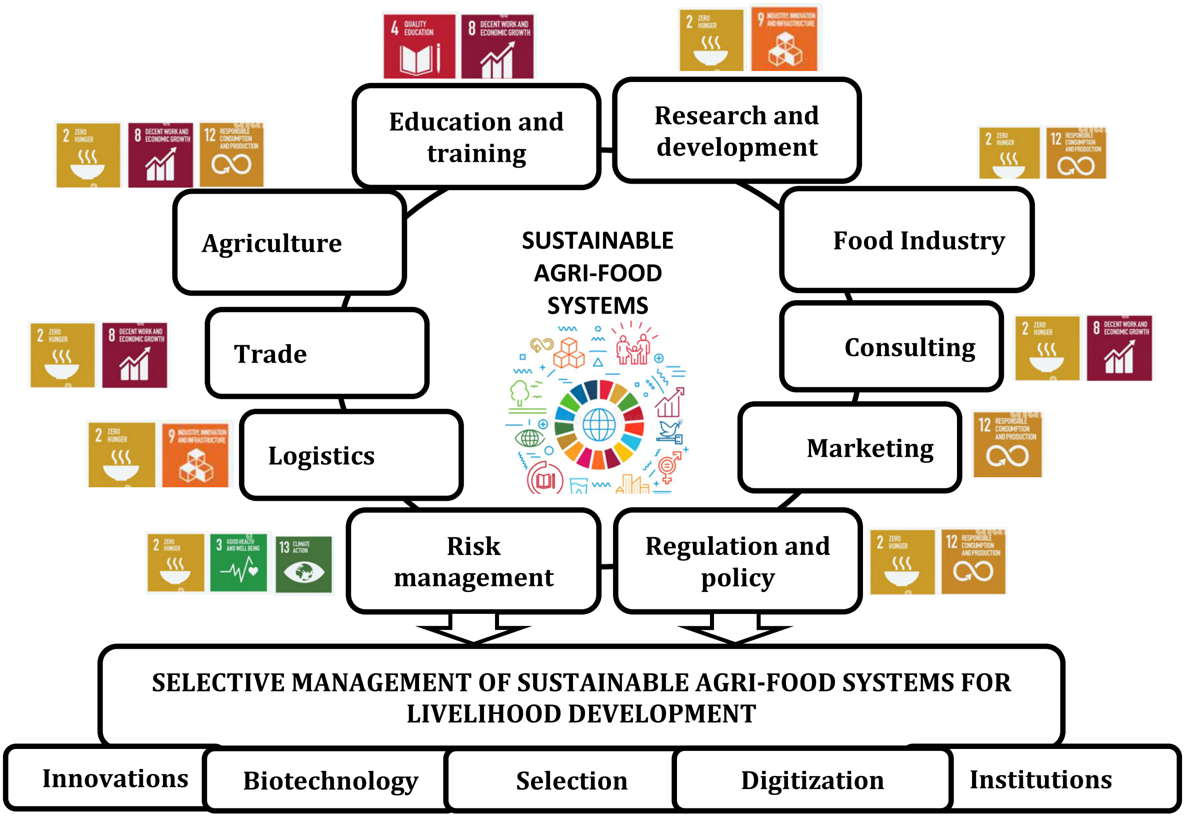

Figure 4. Structural-logical diagram of the scientific inquiry into the toolkit of selective management for sustainable agri-food systems in livelihood development

As per the illustrated model, the foundational framework of a sustainable agri-food system encompasses distinct components, each of which inherently contributes to the realization of corresponding SDGs:

– Agriculture: Contributes to the fulfillment of sustainable development goals: SDG 2 (Zero Hunger), 8 (Decent Work and Economic Growth), and 12 (Responsible Consumption and Production).

– Food Industry: Exerts influence on the attainment of sustainable development goals: SDG 2, 12.

– Trade: Acts as a facilitator for the achievement of sustainable development goals: SDG 2, 8.

– Logistics: Impacts sustainable development goals: SDG 2, 9 (Industry, Innovation, and Infrastructure).

– Marketing: Casts its influence on sustainable development goals: SDG 12.

– Consulting: Contributes to the realization of sustainable development goals: SDG 2, 8.

– Research and Development: Serves as a catalyst for the fulfillment of sustainable development goals: SDG 2, 9.

– Regulation and Policy: Play a role in advancing sustainable development goals: SDG 2, 12.

– Education and Training: Lends support to the attainment of sustainable development goals: SDG 4 (Quality Education), 8.

– Risk Management: Contributes to the achievement of sustainable development goals: SDG 2, 3 (Good Health and Well-being), 13 (Climate Action).

The comprehensive specifics pertaining to within the context of sustainable agri-food systems are meticulously outlined in Table 1.

Table 1. Explanation of the SDGs for sustainable agri-food systems

SDG 1	These sustainable development goals (SDGs) provide the framework for the development and implementation of sustainable agri-food systems.
SDG 2	End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.
SDG 3	Ensure healthy lives and promote well-being for all at all ages.
SDG 4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
SDG 8	Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all.
SDG 9	Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.
SDG 12	Ensure sustainable consumption and production patterns.
SDG 13	Take urgent action to combat climate change and its impacts.

In essence, the study synergistically amalgamated an array of methodologies encompassing traditional selective breeding, contemporary breeding techniques, biotechnological breakthroughs, and mechanisms of financial support. By assimilating insights from these diverse sources, including scholarly literature and expert perspectives, the study achieved an enriched comprehensiveness and bolstered the authenticity of its findings and conclusions [48], [49], [50].

3. Results

The advent of biotechnological advancements has ushered a transformative phase for selective breeding, endowing it with innovative tools and techniques to exert precise control over the reproductive processes in animal and plant domains. These advancements encompass genetic engineering, gene editing, and cloning, unlocking avenues for more expeditious and targeted enhancements in genetic attributes [51], [52]. Although these biotechnologies hold the promise of manifold benefits, ethical, societal, and environmental apprehensions also loom, especially concerning animal welfare, genetic diversity preservation, and inadvertent consequences (Figure 5).

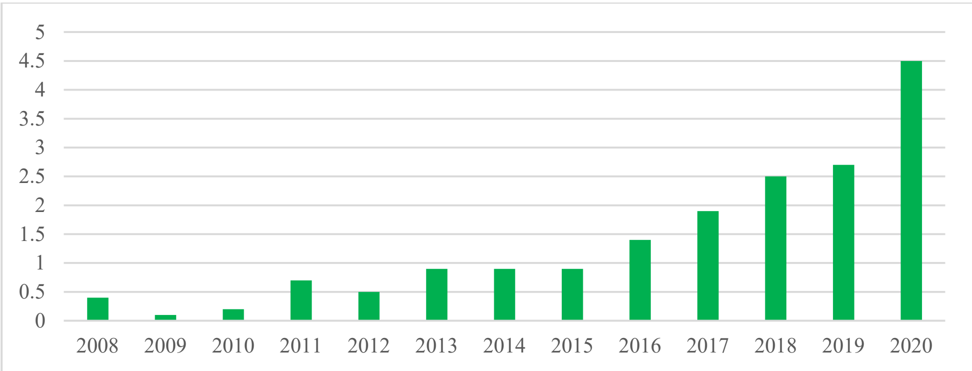

Figure 5. Global investment trends in agricultural technology (AgriTech), 2008-2020 [53]

In tandem with biotechnological strides, the digital transformation of agribusiness has ushered in fresh vistas to enhance the selective management of reproduction processes within the agri-food system. The advent of digital technologies, encompassing precision agriculture, big data analytics, the IoT, blockchain, and (AI), offers a pathway to optimize breeding endeavors, elevate the attributes of animals and plants, and foster transparency and traceability within breeding initiatives.

This digital paradigm has the potential to reshape the agri-food landscape, imbuing it with heightened efficiency, sustainability, and profitability [54], [55]. In summary, the significance of quality and safety within food products remains pivotal and cannot be overstated. These factors stand as pillars for safeguarding consumer health, nurturing consumer trust, fortifying the economic sustainability of the food industry, and adhering to legal mandates [56].

Contemporary methodologies, exemplified by marker-assisted selection, genomic selection, and genome editing, hinge upon strides made in molecular biology and data analysis (Figure 6).

These approaches have markedly heightened the efficiency and accuracy of selective breeding.

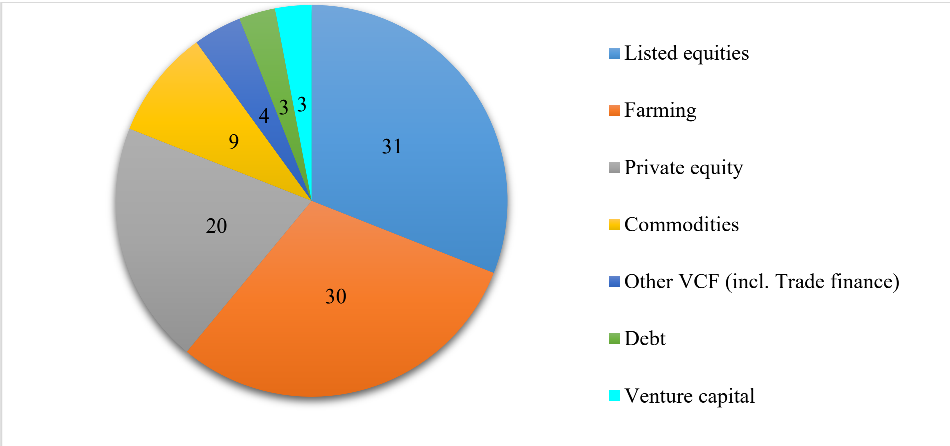

Figure 6. Share of the main investment channels in the F&A sector [57]

As the agricultural landscape evolves, the utilization of these methods could significantly transform food production systems, enhancing food quality, safety, and sustainability while addressing challenges associated with population growth, climate change, and resource constraints.

In terms of financial support for agri-food innovation, the landscape is diverse. Many start-ups seek moderate funding levels, ranging from €25,000 to €100,000, while established innovators may require funding exceeding €100 million (Figure 7). Traditional relationships between borrowers and lenders, often involving commercial banks, remain prominent.

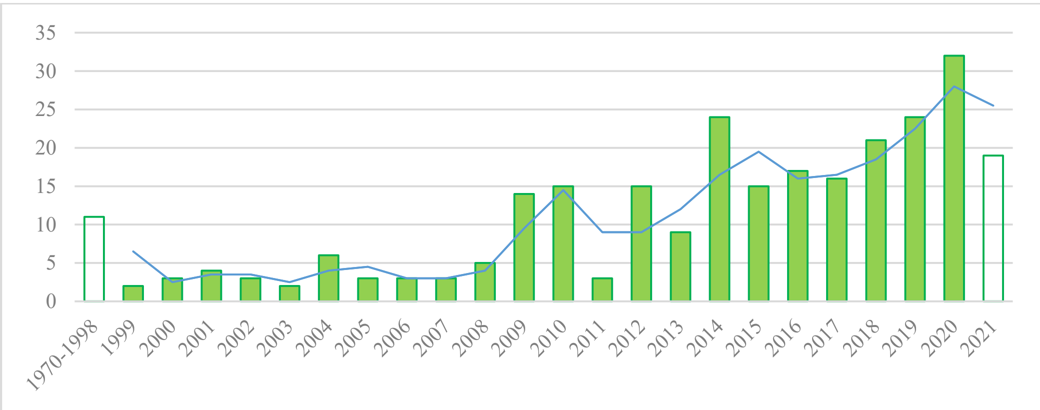

Figure. 7 Number of food-finance nexus-related publications per year (1970-2021) [58]

Traditional relationships between borrowers and lenders, often involving commercial banks, remain prominent.

The EU's research and start-up funding policies play a significant role, with grants being a substantial funding source.

Despite funding opportunities, a significant portion of companies struggle to meet their funding targets, with challenges including the lack of a clear business model and uncertainties around market adoption and commercialization.

Addressing these challenges could involve intelligent funding mechanisms that combine innovation funding with market expertise. Additionally, a desire for advisory services to support agri-food innovators, particularly during the initial phases of establishment. Such support can aid in navigating the complexities of both technological and commercial aspects.

Financial support for agri-food innovation comes from a variety of institutions across different countries and organizations, reflecting a diverse landscape.

The range of funding offered is broad, with most institutions providing financial support in the €50,000 to €20 million range. The timeframes for fund availability vary, spanning from just a few days to a maximum of six months. Additionally, the maturities of these funds range from five to 20 years.

In the process of providing funding, 16% of financiers encountered challenges, while a larger portion (33%) found the process relatively straightforward. A significant portion (40%) remained neutral in assessing the difficulty of funding agri-food companies.

Among agri-food innovators seeking funding, several obstacles were highlighted:

- Lack of proven business model: one-third of innovators identified the absence of a proven business model as a significant challenge.
- Business plan and management challenges: an additional one-third of respondents mentioned challenges tied to a faulty business plan or inadequate management. While these issues classified as insurmountable, they still posed obstacles.
- Commercial opportunities: approximately 23% of respondents expressed concerns over uncertain or overly risky commercial opportunities.
- Financial track record: 16% of respondents identified weak or insufficient financial track records as a hurdle.
- Regulatory environment: stringent regulations were flagged as a challenge by 13% of respondents.

These challenges underscore the complexities and multifaceted nature of agri-food innovation funding. Addressing them may require a combination of refined business strategies, more robust financial records, regulatory reforms, and improved market assessments (Figure 8).

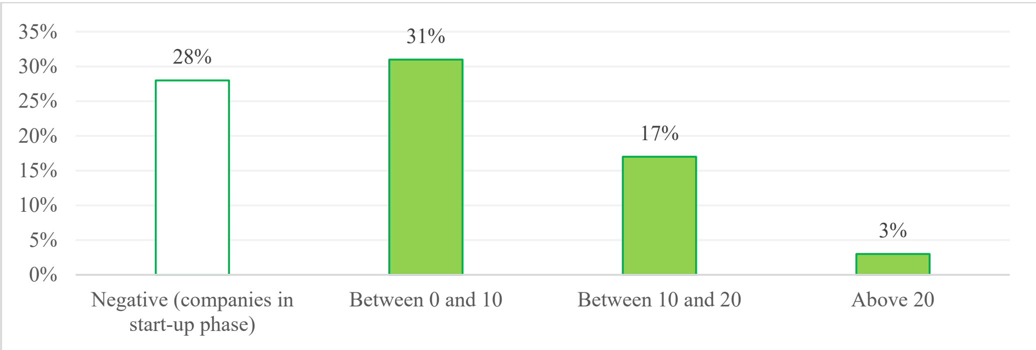

Figure 8. EBITDA margin of companies [59]

In summary, the methods of selective control of reproduction processes hold significant promise for enhancing various aspects of food production, encompassing efficiency, precision breeding, sustainability, and genetic diversity preservation. However, these methods also carry ethical, social, and environmental considerations that require careful attention and resolution to ensure their responsible application.

Furthermore, the ongoing digital transformation of agribusiness is reshaping food production paradigms. Selective control of reproduction processes plays a pivotal role in this evolution. By harnessing cutting-edge technologies gene editing, genetic engineering, and cloning, breeding animals and plants with sought-after traits can be meticulously done, bolstering their resilience, productivity, and overall sustainability. This shift has the potential to bolster food security, diminish waste, and enhance the safety and quality of food supply (Figure 9).

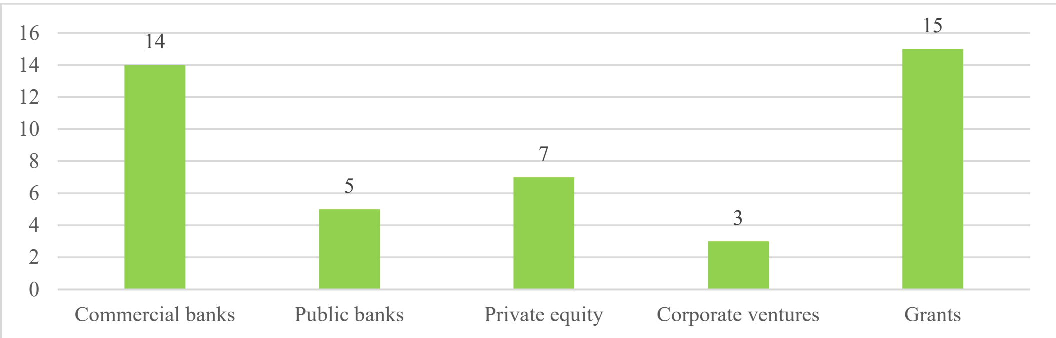

Figure 9. Funding sources of companies

Integration of digital technologies in agribusiness has ushered in a new era of innovation and efficiency. Precision farming, remote sensing, and machine learning are key components of this transformation, enabling farmers to optimize their practices, lower costs, and enhance yields. For instance, precision farming employs data-driven insights to guide decisions related to planting, fertilization, and harvesting. Sensing detects variations in soil conditions, such as moisture levels and nutrient content, influencing crop growth. These technological advancements have far-reaching implications for the agribusiness sector.

Furthermore, the changing landscape of agribusiness is accompanied by novel business models vertical farming, urban agriculture, and community-supported agriculture.

These models emphasize sustainability, local production, and social responsibility. Their implementation is made possible by digital technologies that enhance the efficiency and adaptability of production and distribution systems.

Concerns over data privacy and ownership are paramount, as are issues related to the digital divide, which may hinder equitable access to these technologies. Moreover, the potential risk of power concentration within a few large corporations. Addressing these challenges is vital to ensure that the benefits of digitalization are accessible to all and that the transformation of agribusiness aligns with principles of fairness and sustainability (Figure 10).

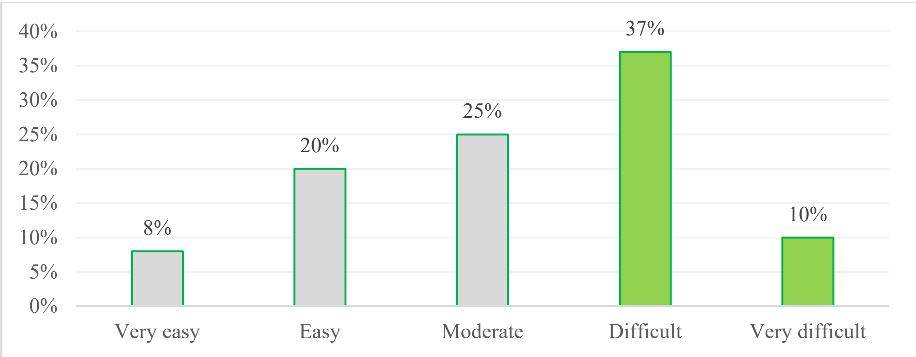

Figure 10. Innovators: perceived difficulty in access to finance

This means that as digital technologies revolutionize the way reproduction processes is managed, there isan opportunity to create a more efficient and balanced agri-food system that benefits all stakeholders involved (Figure 11).

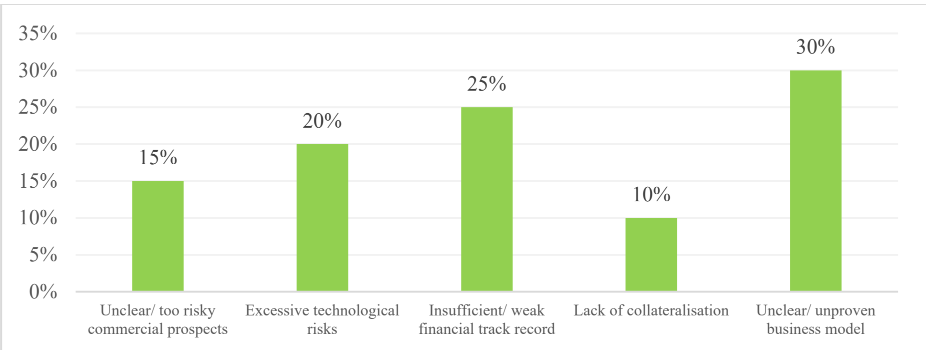

Figure 11. Innovators: reported showstoppers

Integration of precision agriculture, big data analytics, IoT, blockchain, and AI into breeding programs is indeed transforming the landscape of animal and plant production.

Collectively, these technologies empower breeders to create more resilient, productive, and sustainable animals and crops. By combining these advancements with responsible ethical practices, the challenges of food security, sustainability, and environmental stewardship in the face of a growing global population can be addressed (Figure 12).

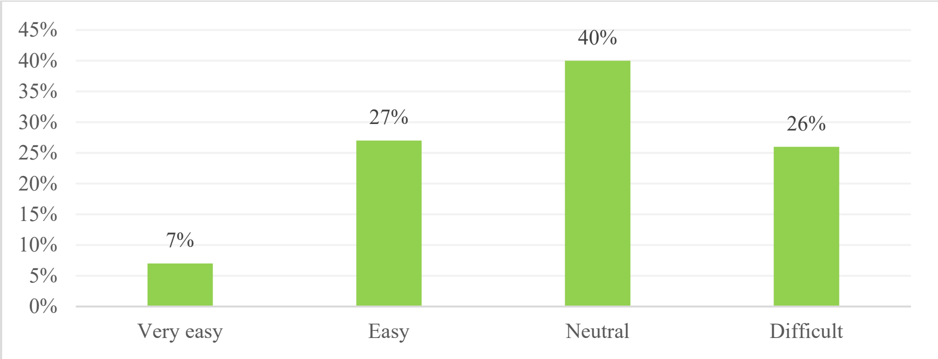

Figure 12. Financiers: Perceived difficulty in access to finance

While digital technologies offer significant potential for refining the selective control of reproduction processes in agribusiness, there are also various challenges and opportunities linked to their application.

One of the primary challenges is the expense of adopting these technologies, which might be prohibitive for certain farmers and breeders. The costs related to procuring and maintaining the essential hardware and software can be substantial, particularly for small-scale farmers who might lack the financial means to invest in new technologies (Figure 13).

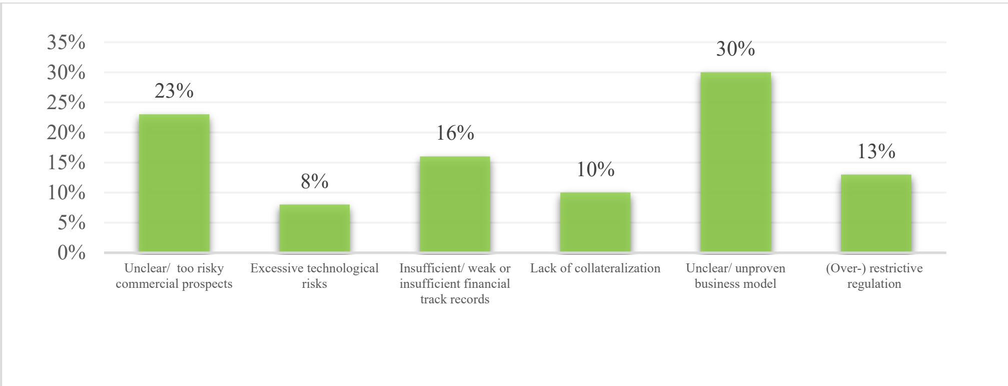

Figure 13. Financiers: reported showstoppers

Additionally, a challenge lies in the requirement for skilled personnel to effectively manage these technologies. Farmers and breeders may need to invest in training programs to ensure they possess the necessary skills and knowledge to utilize digital technologies proficiently. This may pose a specific challenge for older farmers who might not be as familiar with digital technologies as younger generations.

Another challenge is the necessity to address concerns related to data privacy and security. Farmers and breeders must ensure that the data they collect and employ are secure and shielded from unauthorized access, while also adhering to relevant data protection regulations [60].

Digital technologies offer several opportunities for enhancing the selective control of reproduction processes in animal and plant production. These opportunities are outlined in Table 4.

Table 4. Digital technologies present several opportunities

Challenge	Description
Ethical Concerns	The use of genetic engineering, gene editing, and cloning raises ethical concerns. Some people believe that these technologies are unnatural and that they may lead to the creation of organisms with unintended consequences. There are also concerns about the potential for abuse of these technologies, such as the creation of designer babies or the production of genetically modified organisms that are resistant to disease or pests.
Social Concerns	The use of digital technologies in agribusiness may also have social implications. For example, there may be concerns about the impact on traditional farming communities, which may be left behind by the rapid pace of technological change. There may also be concerns about the potential for these technologies to exacerbate inequalities, as farmers who cannot afford to adopt them may be left at a disadvantage.
Environmental Concerns	The use of digital technologies in agribusiness may also have environmental implications. For example, there may be concerns about the impact of genetically modified organisms on biodiversity and the natural environment. There may also be concerns about the impact of intensive farming practices on soil health, water quality, and other environmental factors.
Legal Concerns	The use of digital technologies in agribusiness may also raise legal concerns. For example, there may be concerns about intellectual property rights, such as who owns the genetic data that is collected through breeding programs. There may also be concerns about liability, such as who is responsible if something goes wrong with a genetically modified organism.
Technical Concerns	The use of digital technologies in agribusiness may also face technical challenges. For example, there may be concerns about data security and privacy, as well as the need for robust data management systems to handle the large volumes of data generated by these technologies.

3.1. Sustainable Development in the Agri-Food System and the Environment

Recommendations for promoting sustainable development in the agri-food system:

- Encourage sustainable agricultural practices: Advocate for the adoption of sustainable agricultural practices, including organic farming, agroforestry, and precision agriculture. These practices contribute to the reduction of synthetic inputs, soil erosion, water conservation, and the safeguarding of biodiversity.
- Preserve genetic diversity: Champion the conservation and utilization of genetic diversity in crops and livestock. Achieve this through the preservation of traditional varieties, bolstering seed banks, and endorsing breeding programs centered around maintaining diverse genetic resources.
- Embrace modern selective breeding methods: Embrace contemporary selective breeding methods like genomic selection and marker-assisted breeding. These approaches enhance the efficiency, precision, and sustainability of breeding programs by facilitating more accurate selection for desired traits and reducing the breeding cycle duration.
- Enhance transparency and traceability: Harness digital technologies such as blockchain and IoT to augment transparency and traceability within the agri-food system.
- These technologies empower consumers to make informed decisions, reduce food wastage, and bolster food safety by conveniently tracing the source and quality of food products.
- Prioritize food safety and quality: Strengthen regulations and standards related to food safety to ensure the production, processing, and distribution of safe and premium-quality food items. Implement robust monitoring and inspection systems to identify and avert contamination, guaranteeing compliance with food safety norms.
- Promote: Guide consumers to sustainable food choices by providing information about the environmental and social impact of diverse food products. Advocate for plant-based diets, food waste, and local and sustainable food production and distribution systems.
- Encourage collaboration and knowledge exchange: Foster collaboration among agri-food stakeholders encompassing farmers, producers, processors, distributors, retailers, and consumers. Facilitate the sharing of knowledge and best practices to propagate sustainable development throughout the entire food supply chain.
- Address ethical and social considerations: Acknowledge the ethical and social implications of biotechnological advancements in selective breeding. Ensure responsible use of these technologies, accounting for factors such as animal welfare, biodiversity preservation, and equitable access to the benefits of breeding programs.

– Support financial and advisory services: Extend financial backing and advisory services to agri-food innovators, with particular emphasis on small-scale and start-up ventures. Develop funding mechanisms that blend innovation funding with market expertise, while offering advisory support to assist innovators in constructing viable business models and strategies.

– Invest in research and development: Allocate resources to endorse research and development within sustainable agriculture and selective breeding. Foster collaboration among research institutions, industry players, and farmers to cultivate innovative solutions for sustainable food production.

4. Conclusion and Recommendation

The integration of sustainable development principles into the digitalization of agribusiness offers significant potential to enhance the quality and safety of food products, increase productivity and yield, and promote ethical and environmentally conscious farming practices. By harnessing digital technologies such as precision agriculture, big data analytics, IoT, blockchain, and AI, the breeding programs can be optimized, and animal and plant characteristics improved. The production processes can be monitored in real-time, while ensuring transparency and traceability, therefore, analyzing large datasets to identify patterns and make predictions. Nevertheless, the adoption of these technologies also brings forth ethical, social, and environmental challenges. Hence, it is crucial to carefully address these concerns and develop policies and regulations that promote responsible and sustainable use of digital technologies in agribusiness. Through such measures, the potential of digital technologies to establish a more efficient, sustainable, and equitable food system for everyone can be fully unleashed.

Despite the inherent challenges, the opportunities arising from the selective control of reproduction processes in the digitalization of agribusiness are immense. It is essential to conduct further research and development to comprehend the long-term impacts, address concerns, and establish regulatory frameworks that balance innovation with sustainability and societal well-being. By leveraging advancements in genetic technologies, digitalization, and interdisciplinary collaboration, the full potential of selective control of reproduction processes can be unlocked, contributing to the establishment of sustainable and efficient agri-food systems that meet the growing global demand for safe, nutritious, and environmentally friendly food products.

Ultimately, the selective control of reproduction processes in the digitalization of agribusiness represents a transformative pathway for the future of food production, offering immense opportunities to tackle global challenges while ensuring the well-being of producers and consumers alike.

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