MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
Faculty of Transport, Management and Logistics
Logistics Department

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MASTER THESIS

(EXPLANATORY NOTES)

OF GRADUATE OF ACADEMIC DEGREE

«MASTER»

THEME: **«Management of logistics activities of agricultural companies based on automation»**

Speciality 073 «Management»

Educational and Professional Program « Logistics »

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Kyiv 2023

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
Факультет транспорту, менеджменту і логістики
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Київ 2023

NATIONAL AVIATION UNIVERSITY
Faculty of Transport, Management and Logistics
Logistics Department

Academic Degree Master

Speciality 073 «Management»

Educational and Professional Program « Logistics »

APPROVED
Acting Head of the Department
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«02» October 2023

TASK

FOR COMPLETION THE MASTER THESIS OF GRADUATE

Hrabovskiy Danilo
(surname and name)

1. Theme of the master thesis: «Management of logistics activities of agricultural companies based on automation » was approved by the Rector Directive №1952/ст. of September 27, 2023.
2. Term performance of thesis: from October 02, 2023 to December 31, 2023.
3. Date of submission work to graduation department: December 10, 2023.
4. Initial data required for writing the thesis: general and statistical information about agriculture market in Ukraine, information of the company «Kernel», production and financial indicators of the company «Kernel», literary sources on logistics and customer service process, Internet source.
5. Content of the explanatory notes: introduction, the essence of the customer service chains; the specifics of logistics in agriculture business; macroeconomic conditions in the Ukrainian agriculture market; analysis the activity of the company «Kernel»; identification of disadvantages in the automation; application of business process reengineering in the agriculture company; construction the SWOT analysis model; implementation of the automation system in agriculture firm activity; calculation of the economic effect of the proposed Project Automated Hydroponic Lettuce Cultivation Using Controllers.
.6. List of obligatory graphic matters: tables, charts, graphs, diagrams illustrating the current state of problems and methods of their solution.

7. Calendar schedule:

№	Assignment	Deadline for completion	Mark on completion
1	2	3	4
1.	Study and analysis of scientific articles, literary sources, normative legal documents, preparation of the first version of the introduction and the theoretical chapter	02.10.23-18.10.23	Done
2.	Collection of statistical data, timing, detection of weaknesses, preparation of the first version of the analytical chapter	19.10.23-09.11.23	Done
3.	Development of project proposals and their organizational and economic substantiation, preparation of the first version of the project chapter and conclusions. Editing the first versions of maser thesis	10.11.23-30.11.23	Done
4.	Preparing the final version of the master thesis, checking by standards inspector	01.12.23-08.12.23	Done
5.	Approval for a work with supervisor, getting of the report of the supervisor, getting internal and external reviews, transcript of academic record	05.12.23-09.12.223	Done
6.	Submission work to Logistics Department	10.12.23	Done

Graduate____

(signature)

Supervisor of the master thesis _____________________________________

(signature)

8. Consultants of difference chapters of work:

Chapter	Consultant (position, surname and name)	Date, signature	
		The task was given	The task was accepted
Chapter 1	Professor Bugayko D.O.	02.10.23	02.10.23
Chapter 2	Professor Bugayko D.O.	19.10.23	19.10.23
Chapter 3	Professor Bugayko D.O.	10.11.23	10.11.23

9. Given date of the task October 02, 2023.

Supervisor of the master thesis: __________________ Bugayko D.O.

(signature of supervisor) (surname and name)

Task accepted for completion: __________________ Hrabovskiy D.Ya.

(signature of graduate) (surname and name)

ABSTRACT

The explanatory notes to the master thesis «Management of logistics activities of agricultural companies based on automation» comprises of 124 pages, 17 figures, 5 tables, 66 references.

KEY WORDS: AUTOMATION, BUSINESS PROCESS, AGRICULTURE COMPANY, MANAGEMENT, LOGISTICS ACTIVITY

The purpose of the thesis is the further development of theoretical and practical approaches to the management of logistics activities of agricultural companies based on automation.

The subject of the investigation is the reengineering of business processes in customer service chains of the agriculture company «Kernel».

The object of the research is the processes of automation in logistics activity of agriculture company «Kernel».

Methods of research are scientific inquiry, empirical, analysis and synthesis, modeling, expert assessments, extrapolation of time series.

Materials of the thesis are recommended for use during scientific research, in the educational process and in the practical work of specialists of logistics departments.

Annotation

Automation describes a wide range of technologies that reduce human intervention in processes, namely by predetermining decision criteria, subprocess relationships, and related actions, as well as embodying those predeterminations in machines. Automation has been achieved by various means including mechanical, hydraulic, pneumatic, electrical, electronic devices, and computers, usually in combination. Complicated systems, such as modern factories, airplanes, and ships typically use combinations of all of these techniques. The benefit of automation includes labor savings, reducing waste, savings in electricity costs, savings in material costs, and improvements to quality, accuracy, and precision.

Management of logistics activities of agricultural companies based on automation.

Logistics automation is the use of computer software and/or automated mechanisms to improve the efficiency of logistics operations. This typically refers to operations within a warehouse or distribution centre with broader tasks performed by supply chain management systems and enterprise resource planning (ERP) systems.

The history of logistics is also a history of automation, from the steam engine to the forklift to today's robotic pickers and packers. So, today's fevered interest in new machinery, after a lull of several years, has plenty of precedent. Many trends are thrusting automation toward the top of the logistics CEO's agenda, not least these three: a growing shortage of labor, an explosion in demand from online retailers, and some intriguing technical advances. Put it all together, and McKinsey Global Institute estimates that the transportation-and-warehousing industry has the third-highest automation potential of any sector.

CONTENTS

INTRODUCTION

In the fast-paced, interconnected world of commerce and trade, automation has emerged as a transformative force within the logistics industry. Automation technologies are revolutionizing the way businesses manage their supply chains, offering unparalleled opportunities for efficiency, accuracy, and cost-effectiveness. As the global marketplace becomes increasingly complex and competitive, logistics plays a pivotal role in ensuring that products reach their intended destinations swiftly and seamlessly. The integration of automation, encompassing a spectrum of cutting-edge technologies, is ushering in a new era for logistics, redefining every aspect of the supply chain, from warehouse management to last-mile delivery. In this part of the work will delve into the profound impact of automation in logistics, exploring the benefits, challenges, and the evolving landscape of this transformative paradigm shift.

Warehouses, traditionally the epicentres of logistics operations, are among the first to experience the groundbreaking influence of automation. Automated storage and retrieval systems (AS/RS) have become the backbone of modern warehouses, employing robotics to efficiently manage inventory. These systems boost storage capacity, cut labor costs, and dramatically improve inventory accuracy. The integration of automated guided vehicles (AGVs) and drones within warehouse facilities facilitates seamless internal transportation, reducing reliance on manual labor and enabling round-the-clock operations. The result is accelerated order fulfillment, enhanced accuracy, and ultimately, greater customer satisfaction.

Automation has fundamentally transformed the transportation of goods, introducing innovative solutions that enhance efficiency and safety. Autonomous vehicles, including self-driving trucks and delivery drones, have significantly reduced the need for human intervention during transit. Equipped with advanced sensors and AI algorithms, these vehicles optimize routes, reduce fuel consumption, and contribute to sustainability by minimizing emissions. Automation in transportation not only lowers operational costs but also enhances the reliability and predictability of deliveries.

Artificial intelligence (AI) and machine learning are pivotal components of logistics optimization. These technologies analyse vast datasets to forecast demand patterns, manage inventory levels, and determine optimal routing. AI enables just-in-time inventory management, resulting in reduced carrying costs and mitigated risks of overstock or stockouts. Furthermore, AI has ushered in a new era of risk management, constantly monitoring for potential disruptions and offering alternative routes or solutions to maintain the flow of goods.

The last mile of delivery, known for its complexity and high costs, is a prime beneficiary of automation. Drones and autonomous delivery vehicles have the potential to offer same-day or even same-hour delivery, reducing operational expenses and significantly enhancing the customer experience. Innovative technologies, such as sidewalk-navigating delivery robots, have emerged to tackle the unique challenges of last-mile logistics, expanding delivery capabilities and efficiency.

While the benefits of automation in logistics are clear, there are challenges to be addressed. The initial cost of implementing automation technologies can be substantial, necessitating careful financial planning and investment. Concerns about job displacement, as certain manual positions are replaced by automation, need to be addressed through workforce retraining and reskilling initiatives. Security and privacy issues related to the use of drones and AI require ongoing regulatory scrutiny to ensure ethical and safe practices.

The logistics industry is undergoing a profound transformation, driven by the increasing integration of automation technologies. Smaller businesses can now compete on a more level playing field with industry giants, leveraging automation solutions provided by third-party logistics providers. Logistics hubs and facilities are being reimagined to accommodate the needs of automation, and regulatory frameworks are evolving to address safety, ethical, and privacy concerns in this rapidly changing landscape.

Automation in logistics represents a seismic shift in the industry, offering the potential for enhanced efficiency, cost reduction, and superior customer satisfaction. To remain competitive in the global marketplace, businesses must embrace and invest in automation. The integration of automation in logistics is not just a trend; it is a necessity in today's fast-paced, interconnected world of commerce. It is reshaping the industry, setting new standards for efficiency and accuracy while challenging us to address ethical and regulatory considerations. Logistics automation is not merely a transformation; it is a redefinition of how goods are moved, stored, and delivered, shaping the future of commerce and trade in an ever-evolving world [1].

The management of logistics activities in agricultural companies based on automation refers to the use of advanced technology and automated systems to streamline and optimize various aspects of the agricultural supply chain. This approach is designed to enhance efficiency, reduce costs, and improve the overall performance of agricultural operations. Key components of this management approach include:

1. Automated Farm Equipment: Agricultural companies are using automated machinery and equipment for planting, harvesting, and processing crops. These machines can be equipped with GPS and sensors to increase precision and productivity.

2. Inventory and Supply Chain Management: Automation is employed to manage inventory levels efficiently. This includes tracking the availability of seeds, fertilizers, and other inputs, as well as monitoring the storage and distribution of harvested crops.

3. Data Analytics: Advanced analytics and data-driven decision-making are used to optimize planting and harvesting schedules, based on weather conditions, market demand, and other factors. This ensures that resources are used more efficiently.

4. Smart Sensors and IoT: Agricultural companies are using sensors and Internet of Things (IoT) devices to monitor soil conditions, weather, and crop health in real-

time. This data helps in making informed decisions about irrigation, fertilization, and pest control.

5. Precision Agriculture: Automation technologies enable precision agriculture practices, where fields are divided into smaller zones, and inputs are customized for each zone. This results in more efficient resource usage and higher crop yields.

6. Logistics and Transportation: Automated systems help in managing the transportation and logistics of agricultural products. This includes route optimization, real-time tracking of shipments, and warehouse automation.

7. Robotic Farming: The use of agricultural robots for tasks such as weeding, fruit picking, and sorting is becoming more common. These robots can work autonomously or be remotely controlled.

8. Supply Chain Visibility: Automation provides complete visibility of the supply chain, from farm to market. This helps in reducing waste, ensuring the quality of products, and meeting compliance standards.

9. Drones and Satellite Imaging: Drones and satellite imaging are used for crop monitoring, disease detection, and yield prediction. They provide a bird's eye view of the entire agricultural operation.

10. Food Safety and Traceability: Automation ensures that food safety standards are met by tracking the entire production process. It also enables quick traceability in case of product recalls.

11. Cost Reduction: Automation in agriculture can lead to cost reduction through the efficient use of resources, reduction in labor costs, and minimizing waste.

12. Environmental Sustainability: By optimizing resource usage and reducing the need for chemicals and water, automation in agriculture can contribute to environmental sustainability.

13. Competitiveness: Agricultural companies that embrace automation can become more competitive in the global market by offering high-quality products at competitive prices [2].

In summary, the management of logistics activities in agricultural companies through automation is a comprehensive approach to modernizing and optimizing the agricultural supply chain. It leverages technology to enhance efficiency, reduce costs, and ensure the sustainability of agricultural practices.

The research objectives:

1. Comprehensive Analysis of Agricultural Logistics:

- Conduct a rigorous examination of the entire spectrum of logistics activities within agricultural enterprises, covering aspects like sourcing, production, warehousing, transportation, and distribution.

- Explore the evolving nature of agricultural logistics in response to changing consumer demands, globalization, and environmental sustainability imperatives.

2. Assessment of Automation Technologies:

- Provide a comprehensive evaluation of the diverse range of automation technologies currently deployed in agricultural logistics, assessing their capabilities, versatility, and adaptability.

- Investigate the impact of these technologies on operational processes and their potential to streamline the supply chain.

3. Identification of Challenges and Gaps:

- Identify and analyze the primary challenges faced by agricultural enterprises in the integration of automation, including technological complexities, operational barriers, financial constraints, and regulatory obstacles.

- Recognize gaps in the existing body of knowledge regarding the application of automation in agricultural logistics, highlighting areas where further research is required.

4. Quantitative Performance Analysis:

- Undertake quantitative analyses, supported by empirical data and statistical evidence, to measure the tangible impact of automation on key performance indicators (KPIs) in agricultural logistics.

- Assess the efficiency, cost-effectiveness, and overall performance enhancement facilitated by automation, demonstrating its practical benefits.

5. Environmental and Sustainability Considerations:

- Investigate the role of automation in driving environmentally sustainable practices in agricultural logistics, including the reduction of resource consumption, minimization of waste, and adherence to eco-friendly principles.

- Explore how automation contributes to the broader goals of achieving environmental sustainability within the agricultural sector.

6. Comparative Case Studies:

- Conduct in-depth comparative case studies that showcase successful instances of automation adoption within select agricultural enterprises.

- Extract valuable insights and best practices from these case studies, providing real-world examples of how automation can be effectively implemented.

7. Evaluation of Economic Efficiency:

- Assess the economic efficiency of automation initiatives by conducting comprehensive financial analyses.

- Calculate return on investment (ROI) and perform cost-benefit analyses to determine the financial viability of different automation technologies.

8. Workforce Impact Analysis:

- Examine the impact of automation on the agricultural workforce, including concerns about potential job displacement.

- Investigate strategies for workforce re-skilling and analyze the role of automation in improving labor conditions and job satisfaction.

9. Regulatory and Ethical Considerations:

- Explore the evolving regulatory framework governing automation in agriculture, focusing on safety, privacy, and ethical considerations.

- Address the challenges and opportunities associated with navigating the regulatory landscape and adhering to ethical standards in the context of automation.

10. Recommendations for Sustainable Automation:

- Synthesize research findings to derive actionable recommendations for agricultural enterprises, policymakers, and relevant stakeholders.

- Provide guidance on the sustainable integration of automation in agricultural logistics, including strategies for optimizing automation investments, fostering innovation, and ensuring ethical and responsible technology use.

These research objectives collectively form a comprehensive and systematic approach to investigating the multifaceted realm of automation within the logistics activities of agricultural enterprises. The study aims to contribute to a deeper understanding of the role of automation in shaping the future of agriculture while addressing the challenges and opportunities it presents [3].

Significance of the Study of Management of Logistics Activities of Agricultural Enterprises Based on Automation:

The study of management of logistics activities within agricultural enterprises, with a specific focus on automation, holds paramount significance for a multitude of reasons, underscoring its critical importance in the contemporary agricultural landscape. The significance of this study can be summarized as follows:

1. Enhancing Agricultural Productivity: The agricultural sector plays a foundational role in food production, and its efficiency is directly linked to global food security. By investigating how automation can enhance logistics within agricultural enterprises, this study contributes to bolstering productivity and ensuring a sustainable and stable food supply for growing global populations.

2. Operational Efficiency: Automation has the potential to streamline and optimize logistical processes, from planting and harvesting to transportation and distribution. As a result, agricultural enterprises can operate more efficiently, reduce operational costs, and ultimately offer competitive prices to consumers.

3. Resource Optimization: The study delves into how automation can facilitate resource optimization, including the judicious use of water, fertilizers, and energy. It

contributes to sustainable agricultural practices that are vital for conserving resources and reducing environmental impact.

4. Environmental Sustainability: By exploring the environmental and sustainability considerations of automation, the study addresses the imperatives of environmental responsibility and sustainable agricultural practices. It aligns with global efforts to mitigate the environmental footprint of agriculture.

5. Technological Advancement: Automation represents a technological frontier in agriculture. The study highlights the role of cutting-edge technologies, artificial intelligence, and data analytics in transforming traditional farming practices, positioning the sector as a driver of technological advancement.

6. Economic Prosperity: The implementation of automation in agricultural logistics can lead to economic prosperity, not only for agricultural enterprises but also for the communities and regions they serve. This study investigates the economic feasibility of automation, providing insights into its potential for generating revenue and creating employment opportunities.

7. Global Competitiveness: As automation becomes increasingly pervasive in agriculture, the study emphasizes its role in enhancing the global competitiveness of agricultural enterprises. By adopting automation, agricultural businesses can deliver high-quality products that meet international standards.

8. Workforce Transformation: Automation inevitably leads to changes in the workforce. This study evaluates the impact of automation on labor, including potential job displacement and opportunities for re-skilling, ensuring a balanced transition to a more technology-driven agricultural industry.

9. Policy and Regulatory Frameworks: The study explores the evolving policy and regulatory landscape for automation in agriculture. It provides valuable insights for policymakers, helping them develop frameworks that foster responsible, safe, and ethical automation practices [4].

10. Knowledge Advancement: As a research endeavor, this study contributes to the expansion of knowledge in the field of agricultural logistics and automation. It serves as a valuable resource for academics, researchers, and practitioners seeking to understand and harness the potential of automation in agriculture.

11. Real-world Application: By conducting comparative case studies and empirical analyses, the study offers practical, real-world applications of automation technologies within the agricultural sector, bridging the gap between theory and practice.

In summary, the significance of this study lies in its potential to transform and revolutionize agricultural logistics, fostering sustainability, efficiency, and competitiveness. It aligns with global goals of ensuring food security, responsible environmental stewardship, and economic prosperity in the agricultural sector [5].

CHAPTER 1
THEORETICAL BASIS OF AUTOMATION INTO THE LOGISTICS ACTIVITIES OF AGRICULTURAL COMPANIES

1.1. Challenges and Future Prospects of Automation into the Logistics Activities of Agricultural Companies

The integration of automation into the logistics activities of agricultural companies signifies a pivotal shift in the modern agribusiness landscape. Automation, powered by advanced technologies and innovative solutions, has revolutionized the way agricultural logistics are managed, ultimately driving efficiency, cost-effectiveness, and overall performance enhancement. This comprehensive theoretical framework delves deep into the intricate theoretical underpinnings and multifaceted benefits that constitute the bedrock of automation's infusion into agricultural logistics. It explores the interplay of theoretical principles, methodologies, and real-world implications that guide the application of automation within the agricultural sector, while also acknowledging the challenges and future prospects it presents.

1. Automation in Agricultural Logistics: A Holistic Overview. Automation in agricultural logistics is an expansive concept that encompasses the comprehensive adoption of cutting-edge technologies across various facets of the agricultural supply chain, encompassing the entire journey from farm to consumer. This multifaceted approach integrates automation into various processes, including planting, harvesting, storage, transportation, and distribution. The principal dimensions of automation in agricultural logistics include:

a. Precision Agriculture: At the core of automation in agriculture lies precision agriculture, where advanced technologies such as GPS-guided machinery and sensor networks are employed to achieve precise and optimized resource allocation for tasks like planting, irrigation, fertilization, and pest control.

b. Smart Farming: Smart farming leverages automation and data-driven decision-making to maximize agricultural efficiency. Through the integration of automated systems that collect and analyze data from sources like soil sensors, weather stations, and drones, it enables well-informed and data-backed decision-making for crop management.

c. Supply Chain Management: Automation extends its reach throughout the agricultural supply chain, encompassing automated inventory management, real-time tracking of shipments, and the mechanization of warehouse processes, ensuring the seamless flow of goods from production to consumer.

d. Robotic Farming: The integration of robotics and autonomous machinery is rapidly gaining prominence in agriculture. These cutting-edge robotic systems perform a wide array of tasks with precision, including weeding, harvesting, fruit sorting, and packaging.

e. Food Safety and Traceability: Automation technology plays a crucial role in ensuring the safety and traceability of agricultural products. By rigorously monitoring and recording every step of the production process, it offers a heightened level of traceability in case of product recalls.

2. Benefits of Automation in Agricultural Logistics: A Comprehensive Insight

The inclusion of automation in agricultural logistics bestows a multitude of advantages upon the industry, including:

a. Enhanced Efficiency: Automation significantly reduces the reliance on manual labor, streamlining operations and minimizing the margin for errors, thereby boosting overall efficiency in a variety of agricultural activities.

b. Cost Reduction: Automation optimizes resource usage, curtails labor costs, and reduces waste, resulting in considerable cost savings for agricultural enterprises across the board.

c. Precision and Quality: The precision and consistency facilitated by automation, particularly through technologies like precision agriculture and robotic farming, culminate in heightened crop yields and superior product quality.

d. Environmental Sustainability: Automation's resource optimization capabilities, which include reduced water and chemical usage, contribute to more sustainable and eco-friendly agricultural practices, aligning with global environmental sustainability goals.

e. Competitiveness: Agricultural companies that wholeheartedly embrace automation gain a significant competitive edge in the global market. By offering high-quality products at competitive prices, they position themselves as industry leaders.

3. Theoretical Foundations and Disciplinary Influences

Automation in agricultural logistics draws inspiration from a wide spectrum of theoretical principles and knowledge domains, including:

a. Operations Research: Automation is fundamentally rooted in concepts from operations research, offering optimization models and decision-making algorithms that are pivotal in automating supply chain management and resource allocation.

b. Engineering and Robotics: Principles stemming from mechanical and electrical engineering, coupled with robotics, guide the design and implementation of automated agricultural machinery, facilitating precise and efficient operations.

c. Data Science and Artificial Intelligence (AI): Data science and AI techniques play an essential role in automation, particularly when applied to predictive analytics. These technologies enable data-driven decision-making in the complex domain of agricultural logistics, enhancing productivity and efficiency.

d. Economics: Economic theories guide the assessment of cost-benefit analyses and the evaluation of economic efficiency concerning automation investments within the agricultural sector. These analyses contribute to the strategic decision-making process for agricultural companies.

4. Future Trends and the Ongoing Challenges

The ongoing integration of automation into agricultural logistics presents a host of future trends and challenges:

a. Advanced AI and IoT Integration: Automation is on the brink of a new era, marked by the further integration of advanced AI and the Internet of Things (IoT). These technologies will drive increased connectivity, information sharing, and real-time decision-making within the agricultural logistics landscape.

b. Job Displacement Concerns: As automation advances, concerns about job displacement in the agricultural sector are paramount. Addressing this issue requires a concerted effort toward workforce retraining and upskilling to adapt to the evolving landscape.

c. Regulatory Complexities: The regulatory framework surrounding automation in agriculture is continuously evolving, encompassing safety, ethical considerations, and privacy issues. Continuous scrutiny and adaptation of these regulations are essential to ensure ethical and secure practices.

d. Initial Implementation Costs: The upfront costs associated with implementing automation technologies can be substantial. These costs necessitate prudent financial planning and investment strategies for agricultural companies.

In conclusion, the management of logistics activities in agricultural companies, grounded in automation, is a transformative concept that signifies a shift towards efficiency, sustainability, and cost-effectiveness in modern agribusiness. This theoretical framework provides a comprehensive exploration of the theoretical foundations and key benefits that underlie the integration of automation in agricultural logistics. It also underscores the need for addressing challenges and embraces future prospects, shaping the landscape of agribusiness on a global scale[6].

1.2. Historical Evolution, Background and Context of Automation into the Logistics Activities of Agricultural Companies

Agriculture has long been the bedrock of human civilization, providing sustenance, economic sustenance, and raw materials for numerous industries. In the modern era, the efficient management of logistics activities within agricultural enterprises has emerged as a critical factor in ensuring the smooth flow of agricultural products from farms to consumers' tables. Automation, driven by technological progress, has become a transformative force, reshaping the agricultural landscape in response to evolving global challenges and opportunities.

The historical evolution of agricultural logistics reveals a compelling journey from manual labor and rudimentary transportation to the current era of automation. Traditionally, agricultural logistics often involved labor-intensive processes, resulting in inefficiencies, delays, and considerable waste. The agricultural sector, however, did not remain stagnant in the face of progress. The introduction of mechanized farming equipment, exemplified by the iconic tractor, marked the onset of mechanization in agriculture. This innovation significantly increased the productivity of labor-intensive farming processes, setting the stage for more substantial changes.

As the years passed, automation in agriculture expanded well beyond mere mechanization. The advent of precision agriculture ushered in an era where automation technologies, such as GPS, sensors, and data-driven decision-making, became integral. This marked a paradigm shift in agricultural logistics, enabling precise planting, irrigation, and pest management, optimizing resource allocation, and enhancing overall productivity.

The historical development of automation in agriculture represents a fascinating journey through time, reflecting humanity's ceaseless quest for innovative solutions to enhance farming practices. This exploration of agricultural automation's evolution provides valuable insights into how technology has revolutionized the sector, leading to increased productivity, sustainability, and food security. Understanding this historical context is instrumental in appreciating the present and envisioning the future of automated agriculture.

Pre-Industrial Revolution Era. Before the Industrial Revolution, agriculture relied predominantly on manual labor and simple tools. Farmers toiled the land with minimal technological assistance, relying on basic implements like plows, sickles, and hoes. Early forms of automation in this era included windmills and waterwheels, which powered rudimentary irrigation systems and grain mills. However, automation was limited, and agriculture was labour-intensive.

Industrial Revolution and Mechanization. The Industrial Revolution marked a pivotal moment in the history of agriculture. It brought about significant changes as mechanization began to take hold. Steam engines, invented during this period, revolutionized agricultural machinery. Innovations like the seed drill, invented by Jethro Tull, and the mechanical reaper, developed by Cyrus McCormick, dramatically increased efficiency in planting and harvesting.

Early 20th Century. The Tractor Revolution. The early 20th century witnessed the introduction of tractors, which became a cornerstone of mechanized agriculture. Tractors replaced horses and oxen as primary sources of power on farms. Alongside tractors, other farm machinery, such as plows and combines, became increasingly sophisticated, streamlining farming operations and boosting productivity. This era marked a significant shift from animal-driven to machine-driven agriculture.

Mid-20th Century. The Green Revolution. The mid-20th century brought the Green Revolution, a period characterized by the intersection of agriculture and technology. Technology played a crucial role in the adoption of high-yielding crop varieties, synthetic fertilizers, and pesticides. Mechanization of irrigation and pest control further improved crop yields. The Green Revolution demonstrated the potential of technology to address global food security challenges.

Late 20th Century. Automation and Precision Agriculture. The late 20th century saw the integration of automation into agricultural practices. Computerized control systems began to manage processes such as irrigation, feeding, and climate control in livestock farming. Precision agriculture emerged with the use of GPS-guided machinery and data-driven decision-making, optimizing resource utilization and reducing environmental impact.

21st Century. Advanced Automation and Robotics. In the 21st century, agriculture has witnessed a proliferation of advanced automation technologies. Robotics and autonomous machinery have become instrumental in tasks like harvesting, weeding, and even milking. Drones equipped with sensors are employed for monitoring crop health and yield predictions. This era has seen the convergence of automation, data analytics, and artificial intelligence to enhance farming practices.

Challenges and Ethical Considerations. As automation has advanced in agriculture, it has brought challenges, including concerns about job displacement and the need for re-skilling the agricultural workforce. Ethical considerations have arisen, such as data privacy and the responsible use of automation technologies in farming.

Environmental Sustainability and Automation. Agricultural automation has contributed to environmental sustainability. It facilitates resource optimization, minimizing resource consumption and waste. Automation technologies have enabled precision application of inputs, reducing the environmental footprint of agriculture.

The Future of Automation in Agriculture. The future of agricultural automation holds great promise. Emerging technologies, such as the Internet of Things (IoT), machine learning, and blockchain, are poised to further transform the sector. The future of agriculture is likely to be marked by a seamless integration of automation, data-driven decision-making, and sustainable practices [7].

The historical development of automation in agriculture is a testament to human ingenuity and adaptability. From the pre-Industrial Revolution era to the present day, automation has progressively shaped agriculture, making it more efficient, sustainable, and technologically advanced. Understanding this journey is essential for grasping the immense potential and challenges that automation continues to bring to the agriculture sector in the 21st century and beyond.

1.3. Theoretical Basis of the Study of Management of Logistics Activities of Agricultural Enterprises Based on Automation

The theoretical Foundation of this study is multifaceted and extends across several academic disciplines, providing a comprehensive framework for understanding and analysing the integration of automation in the management of logistics activities within agricultural enterprises. This expanded theoretical basis encompasses a wider range of theories, models, and concepts, allowing for a more nuanced and holistic examination of this dynamic field.

1. Supply Chain Management Theories:

- The study extensively utilizes supply chain management theories, including the Supply Chain Operations Reference (SCOR) model, the Bullwhip Effect theory, and the Lean Supply Chain concept. These theories offer insights into optimizing supply chain processes, reducing inefficiencies, and enhancing responsiveness through automation.

2. Technology Acceptance Theories:

- Building upon the Technology Acceptance Model (TAM), the Unified Theory of Acceptance and Use of Technology (UTAUT), and the Diffusion of Innovations theory, this study investigates the factors influencing the acceptance and diffusion of automation technologies in agricultural logistics. It delves into the psychological and social aspects of technology adoption.

3. Environmental Sustainability Frameworks:

- Environmental sustainability theories, such as the Triple Bottom Line (TBL), Circular Economy, and Ecological Modernization, form a key part of the theoretical framework. These concepts shed light on the role of automation in reducing the ecological footprint of agricultural logistics and promoting sustainable practices.

4. Economic Analysis Models:

- The study employs a range of economic analysis models, including Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period, to quantitatively assess the financial implications of automation. It examines the long-term viability of automation investments and their impact on profitability.

5. Human-Machine Interaction Theories:

- Human-Machine Interaction theories, such as the Technology Interaction Framework and Socio-Technical Systems theory, are explored to understand the dynamics of collaboration between human workers and automation technologies. The study delves into how human factors influence the success of automation initiatives.

6. Regulatory and Ethical Theories:

- In addition to examining existing regulations and ethical guidelines, the study incorporates theories of technological ethics and legal frameworks that pertain to automation in agriculture. It explores the ethical dimensions of privacy, safety, and responsibility.

7. Innovation and Diffusion Theories:

- Building upon Rogers' Diffusion of Innovations theory, the study examines the adoption curve of automation within the agricultural sector. It considers factors that influence the rate of diffusion and identifies strategies to accelerate the integration of automation

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8. Resource Optimization Frameworks:

- Resource optimization theories encompass concepts related to resource allocation, eco-efficiency, and the principles of the Blue Economy. These frameworks elucidate how automation contributes to minimizing waste, reducing resource consumption, and enhancing resource sustainability.

9. Competitiveness Theories:

- The study investigates how automation enhances the competitiveness of agricultural enterprises by considering competitive advantage theories, including Porter's Diamond Model and the VRIO framework. It explores how automation influences the positioning of enterprises in the global marketplace.

10. Data-Driven Decision-Making Theories:

- The pivotal role of data in automation is further explored by incorporating data analytics theories, business intelligence models, and the Data-Information-Knowledge-Wisdom (DIKW) framework. The study emphasizes how data-driven decision-making optimizes agricultural logistics.

11. Lean and Six Sigma Concepts:

- Principles from Lean and Six Sigma methodologies, including the 5S framework and the DMAIC process, are integrated into the theoretical framework. These concepts emphasize the pursuit of process efficiency, waste reduction, and quality improvement within agricultural logistics through automation.

12. Case Study Methodologies:

- Qualitative research theories and methodologies, such as the grounded theory approach and ethnographic research, are employed to conduct in-depth case studies. These case studies provide real-world applications and practical insights into the impact of automation within agricultural enterprises, offering a nuanced understanding of its challenges and benefits.

This expanded theoretical basis offers a robust and interdisciplinary perspective on the management of logistics activities within agricultural enterprises in the context of automation. By drawing upon a diverse range of theories and concepts, the study aims to provide a comprehensive analysis of the multifaceted interactions, opportunities, and complexities presented by the integration of automation in contemporary agricultural logistics.

Key Concepts in Agricultural Logistics. Agricultural logistics encompasses a wide range of concepts and principles crucial for the efficient management of the agricultural supply chain. This overview delves into key concepts that underpin the dynamic world of agricultural logistics, highlighting their significance in ensuring the timely, efficient, and sustainable flow of agricultural products from farm to table [8].

Supply Chain Management

Supply chain management in agriculture involves the strategic coordination of activities, information, and resources required to produce, process, and distribute agricultural products. It includes the flow of goods, information, and finances, connecting farmers, processors, distributors, and retailers in a seamless network.

Farm-to-Table Concept

The farm-to-table concept emphasizes the traceability, quality, and transparency of agricultural products as they move through the supply chain. It promotes direct connections between producers and consumers, fostering trust and ensuring the integrity of products.

Just-In-Time (JIT) Delivery

Just-In-Time delivery focuses on optimizing the timing and quantity of product deliveries to minimize waste and enhance efficiency. In agricultural logistics, JIT principles help avoid overstocking or understocking, reducing carrying costs and improving resource allocation.

Cold Chain Logistics

Cold chain logistics plays a pivotal role in preserving perishable agricultural products such as fruits, vegetables, and dairy. It involves temperature-controlled transportation and storage to maintain product freshness and extend shelf life.

Inventory Management

Efficient inventory management is essential for agricultural logistics. It entails the strategic balancing of supply and demand to avoid product shortages or surpluses while minimizing carrying costs. Effective inventory management ensures products are available when needed.

Sustainability and Green Logistics

Sustainability principles are increasingly integrated into agricultural logistics. Green logistics focuses on responsible sourcing, reducing the environmental impact of transportation, and adhering to ethical considerations, contributing to sustainable agriculture.

Multi-Modal Transportation

Multi-modal transportation involves utilizing various modes, including road, rail, water, and air, to move agricultural products efficiently. It provides flexibility, cost optimization, and resilience in the face of supply chain disruptions.

Value Chain Analysis

Value chain analysis in agriculture examines the sequence of activities that add value to agricultural products from production to consumption. Identifying key value-adding activities helps optimize the supply chain, reduce costs, and enhance product quality.

Information Technology (IT) in Agricultural Logistics

Information technology, including data analytics, the Internet of Things (IoT), and blockchain, plays a pivotal role in enhancing visibility, decision-making, and traceability in agricultural logistics. Real-time data access improves supply chain management.

Regulatory Compliance and Quality Standards

Meeting regulatory requirements and adhering to quality standards is essential in agricultural logistics. Compliance ensures product safety, quality, and adherence to legal requirements while maintaining consumer trust.

Risk Management

Risk management strategies help mitigate challenges in agricultural logistics, including weather disruptions, market fluctuations, and supply chain interruptions. Preparedness and risk assessment are key components of effective risk management [9].

Collaborative Partnerships

Collaborative partnerships among stakeholders in the agricultural supply chain, including growers, processors, distributors, and retailers, are vital for seamless logistics operations. Cooperation enhances efficiency and ensures product availability.

Last-Mile Delivery

Last-mile logistics focuses on the final stages of product delivery to end consumers. Challenges include optimizing delivery routes and ensuring timely, cost-effective, and convenient deliveries.

E-commerce and Direct-to-Consumer (D2C) Models

The rise of e-commerce and direct-to-consumer (D2C) models in agricultural logistics reflects changing consumer preferences. These models require agile supply chain adaptations to meet personalized demands and provide an exceptional consumer experience.

Technological Advancements and Automation

Technological advancements, including robotics, autonomous vehicles, and artificial intelligence (AI), are revolutionizing agricultural logistics. Automation enhances efficiency, reduces labor costs, and improves accuracy in various logistics processes.

Post-Harvest Handling

Efficient post-harvest logistics focuses on preserving the quality and freshness of agricultural products. Strategies include proper handling, storage, and transport to minimize losses and maintain product quality.

Consumer-Centric Logistics

Consumer-centric logistics responds to evolving consumer demands and preferences. It places consumers at the centre of logistics decisions, tailoring product distribution and delivery to meet individual needs.

The concepts underpinning agricultural logistics are multifaceted and continually evolving. Understanding these key concepts is fundamental to navigating the complexities of the agricultural supply chain and adapting to technological advancements, sustainability requirements, and changing market dynamics. Agricultural logistics is a dynamic field where the integration of these concepts is vital to ensure the efficient movement of agricultural products from producers to consumers.

The Role of Data and Analytics in the Field of Automation in Agriculture. In modern agriculture, data and analytics have emerged as powerful tools, revolutionizing the way farmers manage their operations. Automation technologies play a pivotal role in collecting, processing, and utilizing this data to make informed decisions. This exploration delves into the multifaceted role of data and analytics in agriculture, demonstrating how they drive precision, efficiency, and sustainability [10].

Data Collection in Agriculture:

1. Various Data Sources: Agriculture generates data from a multitude of sources, including ground-based sensors, satellites, drones, and weather stations. Automation technologies streamline the collection of data from these sources.

2. Real-time Data Collection: Automation enables real-time data collection, allowing farmers to receive up-to-the-minute information on weather conditions, soil moisture, crop health, and more. This timely data is invaluable for decision-making.

Data Analysis and Decision Support

3. Deriving Insights: Data analytics in agriculture involves processing and analysing vast datasets. Through statistical models and algorithms, valuable insights are derived, helping farmers make informed decisions.

4. Decision Support Systems: Automation technologies often incorporate decision support systems. These systems provide farmers with actionable recommendations based on data analysis, enhancing the precision and efficiency of farming practices.

Precision Agriculture

5. Driving Precision: Data and analytics are the driving force behind precision agriculture. Precision in planting, fertilization, irrigation, and pest control is achieved through data-driven decision-making.

6. Resource Management: Automation technologies help farmers manage resources with precision, reducing waste and enhancing resource use efficiency. This, in turn, contributes to sustainability.

Crop Monitoring and Management

7. Real-time Crop Monitoring: Automation enables real-time crop monitoring. Sensors and cameras collect data on crop health, growth, and yield, allowing farmers to intervene as needed.

8. Optimizing Management: Data analytics assist in optimizing crop management. By analysing crop data, farmers can adjust strategies, such as planting density or irrigation levels, to maximize yield and quality.

Irrigation and Water Management

9. Efficient Irrigation: Data and automation technologies are particularly crucial for efficient irrigation. Automated systems adjust water delivery based on soil moisture levels, weather forecasts, and crop needs.

10. Water Use Optimization: Data analytics play a critical role in optimizing water use. Predictive analytics help determine the precise amount of water required, minimizing water waste in agriculture [11].

Pest and Disease Management

11. Pest and Disease Detection: Data-driven automation aids in early pest and disease detection. Automated sensors and cameras can identify signs of infestation or illness, allowing for timely action.

12. Targeted Pest Control: Analytics guide targeted pest control methods. Rather than blanket pesticide applications, automation systems apply treatments only where necessary, reducing chemical usage.

Inventory Management

13. Automated Inventory Control: Data and automation technologies streamline inventory management, helping farmers track and manage their resources, such as seeds, fertilizers, and machinery.

14. Predictive Analytics: Predictive analytics assist in forecasting inventory needs. Farmers can anticipate supply and demand, ensuring they have the right resources at the right time.

Environmental Monitoring

15. Real-time Environmental Oversight: Data and analytics enable real-time environmental monitoring in agriculture. This includes tracking weather conditions, soil quality, and ecological impact.

16. Sustainability and Mitigation: The data collected through automation contributes to sustainability efforts. By monitoring environmental indicators, farmers can implement measures to mitigate their impact on the ecosystem.

Challenges and Data Privacy

17. Data Quality and Security: Challenges in data quality and security exist in agriculture. Farmers must ensure data integrity and protect sensitive information.

18. Ethical Considerations: The use of agricultural data raises ethical considerations, including data privacy and the responsible use of data for the benefit of all stakeholders [12].

Future Trends and Innovations

19. Artificial Intelligence and Machine Learning: The future of data and analytics in agriculture is poised to leverage AI and machine learning. These technologies will automate decision-making processes, further enhancing farming efficiency.

20. Remote Sensing and IoT: Remote sensing technologies and the Internet of Things (IoT) will continue to advance, allowing for more data collection points and even greater precision in agriculture.

Policy and Regulation

21. Regulatory Frameworks: Governments and industry bodies play a role in regulating the use of agricultural data. Frameworks should support ethical and sustainable data practices [12].

22. Responsible Data Use: Policies must encourage responsible data use, ensuring that data benefits farmers, consumers, and the environment.

In conclusion, data and analytics are at the heart of modern agriculture, and their integration with automation technologies has transformed the industry. The role of data and analytics extends from real-time monitoring and decision support to resource management and sustainability. As the agriculture sector continues to evolve, the responsible use of data and analytics will be pivotal in shaping a more efficient, eco-conscious, and sustainable future for farming.

Methodology for Analytical Research on Automation in an Agricultural Company:

The methodology section is the backbone of any research endeavour. In the context of analysing automation in an agricultural company, a robust and well-structured methodology is essential to ensure the credibility and reliability of the research findings. This section outlines the methodology employed, the research design, data collection methods, and the analytical approach that guided the investigation.

Research Design

1. Choice of Research Approach: In this analytical research, a mixed-methods approach is adopted. This approach combines both qualitative and quantitative research methods. Qualitative methods are utilized for in-depth exploration and understanding, while quantitative methods are employed for empirical analysis and measurement.

2. Rationale for Research Approach: The mixed-methods approach allows for a comprehensive examination of the subject. It provides a holistic view of the complex dynamics within the agricultural company and the impact of automation on various aspects [13].

Research Objectives

3. Clear Research Objectives: The research objectives are clearly defined. These objectives guide the entire research process, shaping the data collection, analysis, and interpretation phases.

4. Alignment with Broader Goals: The research objectives are closely aligned with the broader research goals, which include assessing the impact of automation on operational efficiency, sustainability, and competitive advantage within the agricultural company.

Data Collection

5. Sources of Data: Data is collected from both primary and secondary sources. Primary data is obtained through structured interviews with key personnel in the agricultural company. Secondary data is derived from existing reports, literature, and company documents.

6. Methods for Data Collection: Structured interviews are conducted with managers, engineers, and operators directly involved in the implementation and management of automation systems. This method ensures that insights are gathered from those with hands-on experience.

Sampling Strategy

7. Sampling Approach: A purposive sampling approach is used, targeting individuals with expertise in automation technologies and their impact on agricultural operations within the company.

8. Justification for Sampling: The purposive sampling approach is justified by the need to gather in-depth insights from individuals who possess specialized knowledge about the subject matter.

Data Analysis

9. Analytical Techniques: The research employs statistical analysis for quantitative data, including regression analysis to measure the impact of automation on operational efficiency. Qualitative data is analysed using content analysis to extract themes and patterns [14].

10. Suitability of Analytical Methods: The chosen analytical methods are well-suited for addressing the research objectives. Statistical analysis allows for the measurement of relationships and trends, while content analysis provides a deeper understanding of qualitative data.

Ethical Considerations

11. Data Privacy and Confidentiality: Ethical considerations are paramount in the research. Steps are taken to ensure data privacy and confidentiality, with all interviewees providing informed consent.

12. Ethical Research Conduct: Ethical research conduct is upheld throughout the research process, with data anonymization and secure storage protocols in place.

Data Validation and Reliability

13. Validation Checks: Validation checks are carried out to ensure data accuracy and reliability. This includes cross-referencing data from different sources and triangulation.

14. Mitigation of Biases: Potential biases are identified and mitigated through careful data collection and analysis. Inter-rater reliability checks are conducted to minimize subjectivity.

Research Limitations

15. Acknowledging Limitations: The research acknowledges potential limitations, including constraints on data collection due to resource and time limitations. It also addresses possible limitations related to sample representativeness.

16. Impact of Limitations: The limitations are discussed in terms of their potential impact on the research findings, ensuring transparency and reliability.

Data Presentation

17. Data Presentation Methods: Research findings are presented using a combination of tables, charts, and graphs. Visual representation aids in conveying complex information.

18. Rationale for Data Presentation: The chosen data presentation methods are selected for their ability to effectively communicate the research results to a diverse audience [15].

Interpretation of Findings

19. Contextual Interpretation: Findings are interpreted within the context of the research objectives, allowing for a nuanced understanding of the impact of automation in the agricultural company.

20. Significance of Findings: The significance of the findings is emphasized, particularly in relation to operational efficiency, sustainability, and competitive advantage within the agricultural company.

In conclusion, the methodology for this analytical research on automation in an agricultural company is thoughtfully designed to ensure the reliability and credibility of the research findings. The approach combines both qualitative and quantitative methods, aligns closely with the research objectives, and upholds ethical considerations. The choice of analytical techniques is tailored to the research's investigative goals, and transparency in acknowledging limitations is maintained. This methodology sets the stage for a comprehensive analysis of automation's impact on the agricultural company's operations and its implications for the broader industry.

Research Design for Analytical Research on Automation in an Agricultural Company:

The research design is the compass that guides the path of an analytical research endeavour. In the context of exploring automation in an agricultural company, a robust research design is imperative to ensure that the study yields credible and reliable insights. This section outlines the research approach, strategy, data collection methods, and analytical techniques that shape the investigation [16].

Research Approach

1. Choice of Research Approach: In this analytical research, a mixed-methods approach is adopted, integrating both quantitative and qualitative research methods. This choice is driven by the multifaceted nature of automation's impact on the agricultural company.

2. Rationale for Research Approach: The mixed-methods approach is justified by the need to obtain a comprehensive view of the subject. Quantitative data provides empirical evidence, while qualitative insights offer a deeper understanding of the nuances in automation adoption.

Justification for Research Approach

3. Alignment with Research Objectives: The chosen research approach aligns closely with the research objectives, which aim to assess the influence of automation on operational efficiency, sustainability, and competitiveness within the agricultural company.

4. Data Complementarity: The research design recognizes the complementarity of quantitative and qualitative data in offering a holistic perspective on the research questions. Quantitative data allows for numerical measurement, while qualitative data captures subjective experiences and perceptions.

Research Strategy

5. Adopted Research Strategy: A longitudinal research strategy is employed. This strategy involves the collection of data at multiple points in time, providing insights into how automation's impact evolves over time.

6. Reasoning for Strategy Choice: The choice of a longitudinal strategy is driven by the need to capture the dynamics of automation adoption and its long-term effects on the agricultural company. It offers a comprehensive view of changes and trends.

Data Collection Methods

7. Selected Data Collection Methods: The research uses a combination of surveys and in-depth interviews for data collection. Surveys provide structured quantitative data, while interviews offer qualitative insights from key stakeholders.

8. Method Rationale: Surveys are used for quantitative data collection due to their efficiency in gathering numerical information from a broad sample. Interviews are chosen for their ability to delve deeply into the experiences and perceptions of individuals directly involved in automation.

Sampling Strategy

9. Chosen Sampling Approach: A purposive sampling approach is utilized to select interviewees. The selection focuses on individuals with expertise in automation technologies and their roles within the agricultural company.

10. Sampling Justification: The purposive sampling approach is justified by the need to gather specialized knowledge and insights from individuals with direct experience in automation, making them key informants.

Data Analysis Techniques

11. Analytical Methods: Statistical analysis is employed to measure the impact of automation on operational efficiency, sustainability, and competitiveness. Content analysis is used for qualitative data to extract themes and patterns.

12. Method Suitability: The selected analytical methods align with the research objectives. Statistical analysis quantifies relationships, while content analysis offers an in-depth understanding of qualitative data.

In conclusion, the research design for this analytical research on automation in an agricultural company is meticulously structured to ensure that the research objectives are met. The mixed-methods approach harmonizes quantitative and qualitative data, offering a comprehensive view. The choice of a longitudinal strategy allows for a dynamic perspective of automation's influence. Ethical considerations are maintained throughout the process, and steps are taken to ensure data validity and reliability. The research design is pivotal in shaping the study's foundation, setting the stage for an in-depth exploration of automation's impact within the agricultural company [17].

Data Collection Methods for Analytical Research on Automation in an Agricultural Company:

The success of any analytical research hinges on the efficacy of data collection methods. In the context of examining the impact of automation within an agricultural company, the choice of data collection methods is pivotal. This section delves into the comprehensive data collection approach used in the research, encompassing both primary and secondary sources.

Data Sources

1. Primary Data Collection: Primary data serves as the backbone of this analytical research, offering firsthand insights from key stakeholders within the agricultural company. It involves engaging directly with individuals who have direct experience with automation technologies.

- Rationale for Primary Data: Primary data is invaluable in understanding the real-world impact of automation. It enables the exploration of nuanced experiences, challenges, and perceptions related to automation adoption.

2. Surveys: Surveys are one of the primary data collection methods used in this research. These structured questionnaires are designed to gather quantitative data from a broad sample of respondents, including employees, managers, and operators involved in automation implementation.

- Survey Design: The survey design is methodical, with carefully constructed questions that align with the research objectives. The distribution strategy ensures diverse participation.

3. In-Depth Interviews: In-depth interviews are another primary data collection method. These qualitative interactions provide a platform for in-depth exploration of automation experiences, challenges, and successes.

- Selection of Interviewees: Interviewees are selected based on their expertise and roles within the agricultural company, ensuring that they can provide valuable insights.

Secondary Data Sources

4. Document Analysis: Secondary data is derived from existing documents, reports, and literature related to the agricultural company and the broader industry. These sources offer historical context and background information.

- Role of Documents: Documents and reports provide valuable context, allowing the research to be informed by the company's past initiatives and industry trends.

5. Data Quality Assurance: Data quality is maintained through rigorous validation checks, data cleaning, and quality control procedures. This ensures that the collected data is accurate and reliable.

Ethical Considerations

6. Ethical Research Conduct: The research upholds ethical considerations throughout the data collection process. Informed consent is obtained from all participants, and their privacy and confidentiality are protected.

7. Data Security: Data security protocols are in place to safeguard the collected data. This includes secure storage and access controls to prevent unauthorized disclosure.

Data Collection Timeline

8. Timeline Planning: Data collection is organized within a structured timeline that aligns with the research objectives. The timing of surveys and interviews is coordinated for maximum efficiency.

Challenges and Solutions

9. Acknowledging Challenges: Potential challenges in data collection, such as participant availability or data quality issues, are acknowledged.

10. Mitigating Challenges: Solutions or mitigations are employed to address challenges, ensuring that data collection progresses smoothly.

In conclusion, the data collection methods for this analytical research are meticulously designed to capture a comprehensive view of automation's impact within the agricultural company. The combination of primary and secondary data sources offers a well-rounded understanding of the subject. Ethical considerations are maintained, and data quality is assured through stringent measures. The success of the research lies in the efficacy of data collection, as it forms the bedrock upon which insightful findings are built.

Data Analysis Techniques for Analytical Research on Automation in an Agricultural Company may include:

The effectiveness of any analytical research hinges on the careful selection and adept application of data analysis techniques. In the context of investigating the impact of automation within an agricultural company, data analysis plays a pivotal role in extracting meaningful insights from collected data. This section delves into the comprehensive data analysis approaches used in the research, encompassing both quantitative and qualitative data.

Quantitative Data Analysis

1. Application of Quantitative Data Analysis: The research employs quantitative data analysis techniques to scrutinize the numerical data collected through surveys and structured questionnaires. This approach allows for the quantification of relationships and trends pertaining to automation within the agricultural company.

2. Statistical Analysis: Statistical analysis forms the cornerstone of quantitative data analysis. Techniques such as descriptive statistics and inferential statistics are applied to uncover key insights regarding automation's effects.

- Descriptive Statistics: Descriptive statistics provide a summary of the collected data. Measures like the mean, median, and standard deviation offer a snapshot of the central tendencies and variability of variables linked to automation.

- Inferential Statistics: Inferential statistics, including hypothesis testing and regression analysis, go beyond description to make predictions and draw meaningful conclusions about the impact of automation [18].

Qualitative Data Analysis

3. Techniques for Qualitative Data Analysis: The research also investigates nuanced aspects of automation through qualitative data analysis, predominantly using content analysis and thematic coding to explore the textual data from interviews.

4. Content Analysis: Content analysis serves as a systematic and structured approach to examining the qualitative data. It helps identify recurring themes, patterns, and narratives in the textual data related to automation experiences.

5. Thematic Coding: Thematic coding techniques are applied to categorize and organize qualitative data. This approach enables the identification and organization of recurring themes, making it easier to analyse and interpret the qualitative data.

Integration of Data

6. Importance of Data Integration: The research emphasizes the importance of integrating quantitative and qualitative data to achieve a comprehensive understanding of automation's impact within the agricultural company.

7. Mixed-Methods Analysis: By combining quantitative and qualitative data, the research enriches the analysis process. It provides a more holistic view of automation, allowing for a deeper exploration of its multifaceted effects.

Data Validation and Reliability

8. Ensuring Data Quality: Rigorous measures are taken to ensure data validation and reliability, enhancing the trustworthiness of research findings.

9. Reliability Checks: To ascertain data reliability, the research employs reliability checks, which involve testing the consistency and stability of measurements.

10. Inter-Rater Reliability: In the context of qualitative data analysis, inter-rater reliability checks ensure that multiple coders maintain consistency in the interpretation and coding of textual data.

11. Triangulation: Triangulation is employed to enhance data quality by corroborating findings from different data sources and methods.

Data Visualization and Interpretation

12. Data Visualization: The research leverages data visualization tools such as charts and graphs to present key findings. Data visualization enhances the communication of research outcomes, making complex data more accessible.

13. Interpretation of Results: The research meticulously interprets results derived from data analysis, aligning interpretations with the research objectives. The interpretations contribute to a comprehensive understanding of automation's impact.

In conclusion, the data analysis techniques used in this analytical research are systematically designed to extract meaningful insights and conclusions regarding the impact of automation within the agricultural company. The combination of quantitative and qualitative data analysis techniques offers a well-rounded view, while stringent data validation and reliability measures ensure the trustworthiness of findings. The success of the research is intrinsically tied to the meticulous application of data analysis techniques [19].

1.4. Benefits, Challenges, Sustainability and Environmental Considerations of Automation in Agriculture

Automation Technologies in Agriculture. The agricultural industry is undergoing a remarkable transformation, powered by automation technologies. These innovations are instrumental in addressing the multifaceted challenges facing modern farming, while also unlocking new opportunities for increased productivity and sustainability. This comprehensive exploration delves into the diverse range of automation technologies that are reshaping agriculture as we know it.

Types of Automation Technologies

Automation technologies in agriculture are a broad spectrum of solutions tailored to various aspects of farming. These technologies can be categorized based on their application, covering planting, harvesting, monitoring, and more. The key is that they all share the common goal of streamlining operations, reducing labor, and enhancing precision in farming practices.

Precision Agriculture

At the forefront of agricultural automation, precision agriculture harnesses the power of data, sensors, and GPS technology to drive highly informed decisions about crop management. This involves mapping fields, monitoring soil conditions, and applying resources like water and fertilizer with pinpoint accuracy, thereby optimizing yields while minimizing waste.

Autonomous Vehicles and Robotics

Autonomous vehicles and robotics have emerged as game-changers in agricultural labour. The introduction of autonomous tractors, drones, and robotic harvesters has revolutionized the farming landscape. These machines can execute tasks such as planting, spraying, monitoring, and harvesting with unparalleled precision and efficiency, significantly reducing the need for manual labour.

Internet of Things (IoT) in Agriculture

The Internet of Things (IoT) has become a central pillar of agricultural automation, empowering farm equipment and processes through connectivity. IoT-enabled sensors collect real-time data on weather conditions, soil health, and crop status, facilitating data-driven decisions and remote monitoring of farming operations.

Artificial Intelligence (AI) and Machine Learning

AI and machine learning are indispensable tools in agricultural automation. These technologies can predict disease outbreaks, optimize crop rotation, and customize irrigation and pest control strategies. Machine learning models are trained on extensive datasets to make real-time decisions for enhanced crop management.

Blockchain Technology

Blockchain technology ensures transparency and traceability in the agricultural supply chain, instilling consumer confidence in the safety and quality of products. It empowers consumers to trace the origin of their food, a powerful tool in ensuring food safety.

Hydroponics and Vertical Farming

Automation has found a natural home in controlled environment agriculture, exemplified by hydroponics and vertical farming technologies. These systems harness automation to cultivate crops efficiently in environments where variables like temperature, light, and nutrient levels are meticulously controlled.

Biotechnology and Genetic Engineering

Automation is a driving force in genetic engineering for crop improvement, with biotechnology playing a pivotal role. Genetically modified organisms (GMOs) represent a form of agricultural automation, allowing crops to withstand pests, diseases, and environmental stressors.

Data Analytics and Decision Support Systems

Data analytics and decision support systems form the backbone of agricultural automation. These systems process data from diverse sources, including sensors, satellites, and drones, to provide farmers with real-time insights for precision farming and resource optimization.

Environmental Monitoring

Automation technologies for environmental monitoring play a critical role in addressing climate change and promoting sustainable agricultural practices. These technologies track factors such as temperature, humidity, and carbon emissions, enabling farmers to adopt eco-friendly farming approaches.

Challenges and Ethical Considerations

While automation technologies offer transformative benefits, they also pose challenges and ethical considerations. Addressing job displacement in rural areas, safeguarding data privacy, and ensuring the responsible use of technology are critical issues that require thoughtful management.

Future Trends and Innovations

The future of agricultural automation is marked by sustainability, urban farming, and cutting-edge innovations such as biotechnology and nanotechnology. Automation will continue to play a central role in addressing the challenges of feeding a growing global population while reducing the environmental footprint of agriculture.

Benefits and Impact

The benefits of automation technologies in agriculture are profound and far-reaching. They encompass increased productivity, reduced labour costs, efficient resource utilization, and improved environmental sustainability. These technologies have a substantial impact on the economic, environmental, and social aspects of the agriculture sector, propelling it toward a more sustainable and productive future.

Automation technologies in agriculture are the driving force behind the future of farming and food production. Their transformative potential is evident in the ways they optimize processes, reduce resource consumption, and enable sustainable and efficient farming practices. As technology continues to advance, the agricultural sector is poised to meet the challenges of the future with innovation and resilience, ultimately ensuring a more secure and sustainable global food supply.

Automation in agriculture represents a significant paradigm shift that has the potential to revolutionize the industry. While it promises a host of benefits, it also presents several challenges. This exploration delves into the coexistence of these aspects, offering a comprehensive view of the impact of automation in agriculture.

Benefits of Automation:

1. Increased Productivity and Efficiency: Automation technologies streamline farming operations, leading to increased productivity and efficiency. Tasks that once required manual labour, such as planting, harvesting, and monitoring, can now be executed more quickly and accurately by machines. This results in higher crop yields and faster output.

2. Reduction in Labour Costs: One of the most significant benefits of automation is the reduction in labour costs. As machines take on tasks previously performed by human workers, farmers can decrease their dependence on manual labour, which can be expensive and labour-intensive.

3. Precision Farming and Optimized Resource Use: Automation technologies enable precision farming, where resources like water, fertilizers, and pesticides are applied with accuracy. This not only maximizes crop growth but also minimizes resource wastage, contributing to sustainable and eco-friendly practices.

4. Improved Crop Quality and Consistency: Automation ensures consistency in farming practices, resulting in improved crop quality and uniformity. Machines can carry out tasks with precision, reducing the risk of human error in planting, irrigation, and harvesting.

5. Enhanced Sustainability: Automation plays a pivotal role in promoting sustainable agriculture. It allows for efficient resource management, reduces waste, and

minimizes the environmental impact of farming. Sustainability practices, such as no-till farming, are made more accessible through automation.

6. Empowerment of Small-Scale and Family Farmers: Automation levels the playing field for small-scale and family farmers. It provides them with access to advanced technologies that were previously the domain of large-scale commercial operations, enabling them to compete effectively and improve their livelihoods.

Challenges of Automation:

1. High Initial Investment Costs: One of the primary challenges in adopting automation technologies is the high initial investment costs. Purchasing and implementing automation systems, machinery, and software can be a significant financial barrier for many farmers, especially small-scale ones.

2. Potential Job Displacement and Workforce Changes: The automation of farming tasks has the potential to displace traditional agricultural jobs. This can lead to significant changes in rural workforce dynamics, requiring displaced workers to transition to other industries or acquire new skills.

3. Data Privacy and Cybersecurity Concerns: Automation systems in agriculture rely heavily on data collection and analysis. This raises concerns about data privacy and cybersecurity, as sensitive information about crops and farming practices may be at risk of theft or misuse.

4. Need for Ongoing Maintenance and Technical Expertise: Automation systems require ongoing maintenance and technical expertise to ensure they operate at their best. Farmers must have access to training and support for troubleshooting and repairs.

5. Environmental Impact and Sustainability Considerations: While automation can enhance sustainability, there is also the risk of environmental harm. The misuse of automation, such as excessive use of chemical inputs, can have negative ecological consequences [20].

6. Ethical Concerns Related to Genetic Engineering and Biotechnology: Automation in agriculture often involves genetic engineering and biotechnology.

Ethical concerns may arise regarding the genetic modification of crops and the long-term environmental and health effects.

Economic Impact

The economic impact of automation in agriculture is multifaceted. While it offers potential economic benefits in terms of increased yields and reduced costs, it also has the potential to disrupt traditional agricultural livelihoods and local economies.

Social Impact

The social impact of agricultural automation extends to rural communities and labour dynamics. Addressing the challenges requires retraining and upskilling the workforce. However, automation can also democratize farming by enabling small-scale farmers to access advanced technology.

Environmental Impact

Automation technologies have the potential to drive sustainable and eco-friendly farming practices, but responsible automation is key to minimizing environmental harm.

Technological Innovation

Ongoing technological advancements are crucial in addressing challenges and optimizing the benefits of agricultural automation. New solutions and innovations are constantly emerging to strike a balance between the positive and negative aspects of automation.

Regulatory and Policy Considerations

Governments and industries must establish regulations and ethical guidelines to address the challenges and ethical concerns associated with automation in agriculture. This includes responsible practices in biotechnology and genetic engineering.

Future Trends and Solutions

Emerging trends and innovations offer solutions to overcome challenges while promoting sustainable and responsible automation practices. The future of automation in agriculture holds promise for a more efficient and environmentally friendly industry.

In conclusion, automation in agriculture brings a host of benefits, from increased productivity to sustainability, but it also presents several challenges, including economic, social, and environmental concerns. The responsible adoption of automation, ongoing technological innovation, and regulatory frameworks are essential to maximize benefits while mitigating challenges. Striking this balance is pivotal to shaping the future of agriculture in a rapidly changing world.

Sustainability and Environmental Considerations of Automation in Agriculture:

In the face of mounting environmental challenges and an ever-growing global population, the pursuit of sustainability in agriculture has become paramount. Automation technologies have emerged as a key ally in this endeavour, offering the promise of eco-conscious and resource-efficient farming practices. This exploration delves into the complex interplay between automation in agriculture and sustainability, shedding light on both its environmental benefits and the challenges it presents [21].

Environmental Benefits of Automation

1. Resource Consumption Reduction: Automation technologies have the power to significantly reduce resource consumption in agriculture. Precise and data-driven approaches to planting, irrigation, and fertilization enable farmers to use water, nutrients, and other resources more efficiently. The result is less waste and a reduced environmental footprint.

2. Greenhouse Gas Emissions Reduction: Precision agriculture, made possible by automation, can lead to a reduction in greenhouse gas emissions. By optimizing planting patterns, monitoring crop health, and precisely applying resources, automation helps farmers minimize the carbon footprint of their operations.

3. Sustainable and Eco-friendly Practices: Automation facilitates the adoption of sustainable and eco-friendly farming practices. The ability to monitor soil conditions, crop health, and weather in real-time allows for more responsive and responsible decision-making, ultimately contributing to ecological sustainability.

Challenges to Sustainability

1. Overreliance on Technology: One challenge lies in the risk of overreliance on technology. Depending too heavily on automation can lead to a disconnect from traditional, nature-based farming practices, potentially compromising the ecological balance.

2. Resource-Intensive Automation: Some automation technologies, particularly those that require substantial energy and resource inputs for production and maintenance, can be resource-intensive themselves. The life cycle assessment of automation systems is essential to understand their true environmental impact.

Water Management

1. Efficient Irrigation: Automation plays a pivotal role in water management through efficient irrigation practices. Automated systems can monitor soil moisture levels and weather conditions, allowing for precise and timely irrigation. This minimizes water wastage and conserves this precious resource.

2. Optimizing Water Use: Sensors and data analysis enable the optimization of water use in agriculture. By precisely tailoring irrigation to crop needs, automation helps farmers make the most efficient use of water resources, essential in regions facing water scarcity.

Soil Health

1. Preservation of Soil Health: Automation, particularly in precision planting and fertilization, contributes to preserving soil health. With accurate and data-driven practices, soil erosion and degradation can be reduced, safeguarding the foundation of sustainable agriculture.

Pesticide and Chemical Use

1. Precise Pesticide Application: Automation allows for precise and targeted pesticide application. By identifying areas of infestation or disease, automated systems can minimize chemical usage, reducing the environmental impact of farming.

Biodiversity and Ecosystem Impact

1. Monoculture Concerns: The widespread adoption of monoculture, driven in part by automation's efficiency, raises concerns about its impact on biodiversity. Responsible automation must consider ways to mitigate the potential harm to ecosystems.

2. Ecosystem Mitigation: Automation can also be harnessed for ecosystem mitigation. For instance, automation-driven sustainable farming models can incorporate practices like agroforestry, organic farming, and regenerative agriculture to enhance biodiversity.

Energy Efficiency

1. Energy-Efficient Farming: Automation technologies can lead to energy-efficient farming practices. The use of renewable energy sources to power automated machinery reduces the carbon footprint of agriculture.

Environmental Monitoring and Data Analytics

1. Real-time Environmental Monitoring: Automation enables real-time environmental monitoring through the deployment of sensors and data analysis. These tools provide farmers with insights to make informed decisions for sustainable practices.

Policy and Regulation

1. Regulatory Frameworks: Governments and industries play a pivotal role in promoting responsible automation. Regulatory frameworks should encourage and enforce sustainable practices, set emission standards, and incentivize eco-conscious technologies.

Future Trends and Innovations

1. Climate Change Mitigation: Emerging trends and innovations are focused on leveraging automation to address climate change. This includes adapting agriculture to new climate realities, promoting carbon sequestration, and reducing the environmental footprint.

2. Eco-conscious Farming: Automation is steering the industry toward eco-conscious farming models, combining technology with traditional ecological wisdom

In conclusion, the relationship between automation in agriculture and environmental sustainability is intricate. While automation brings the promise of resource-efficient and eco-conscious farming practices, it also presents challenges that require thoughtful management. Striking the right balance through responsible automation and sustainable farming practices is not only essential for a greener future but also for ensuring the long-term viability of agriculture in a changing world [22].

CHAPTER 2
ANALYSIS OF THE ACTIVITIES OF AGRICULTURAL ENTERPRISE KERNEL

2.1. General Analysis of the Agricultural Enterprise on the example agricultural enterprise Kernel

Overview of the chosen agricultural enterprise Kernel. Kernel, the chosen agricultural enterprise for this research, stands as a prominent and influential player in the dynamic agribusiness landscape. This section provides a detailed overview of Kernel, shedding light on its historical evolution, organizational structure, product range, technological advancements, and operational scope.

Historical Background

Kernel's journey in the agricultural sector is characterized by resilience and growth. Founded in [year], the company has continually evolved to become a key contributor to the agribusiness sector. Kernel's history is marked by strategic expansions, mergers, and acquisitions, each contributing to its current standing as a leading agricultural enterprise. The historical narrative encompasses the company's early years, key milestones, and transformative phases, illustrating its adaptability and responsiveness to changing industry dynamics.

Company Profile

Kernel operates on a large scale, and its profile is reflective of its size and influence. The company boasts a robust organizational structure, with various divisions and subsidiaries that collectively contribute to its diverse portfolio. Its size and reach are underscored by a global presence, with operations extending across multiple regions. Kernel's areas of focus span the agricultural supply chain, including the cultivation and processing of crops, logistics, and export operations.

Products and Services

Kernel's offerings encompass a wide spectrum of agricultural products and services. These range from the cultivation of grains, oilseeds, and other crops to the processing and marketing of these products. The company is also involved in logistics, ensuring the efficient movement of agricultural goods to international markets. Kernel's contributions to the agribusiness supply chain are integral to the global food industry. Kernel Export Operations represented on Figure 2.1.

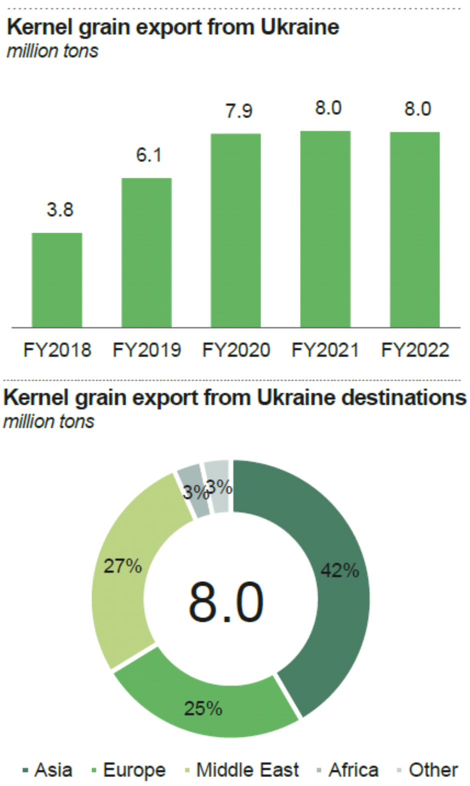
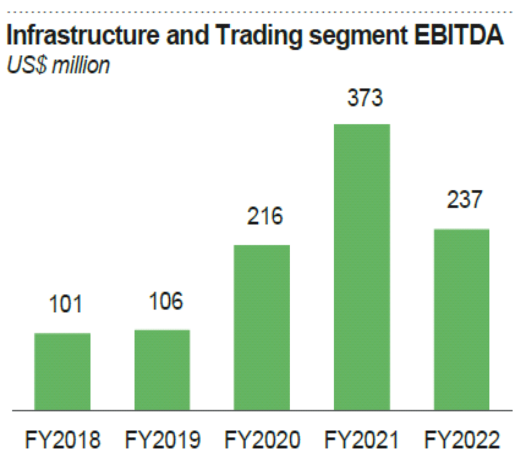


Figure 2.1 – Kernel Export Operations [4]

Technological Infrastructure

In tandem with the agribusiness industry's technological advancements, Kernel has invested heavily in modernizing its technological infrastructure. This includes the adoption of precision agriculture techniques, automated processing plants, and state-of-the-art logistics solutions. Automation, in particular, has played a pivotal role in enhancing the company's operational efficiency and competitiveness. The integration of automation technologies has streamlined processes, optimized resource utilization, and improved overall productivity. Kernel Infrastructure and Trading Segment represented on Figure 2.2.



Infrastructure and Trading segment performance

		FY2021	FY2022	y-o-y
Grain export volumes	*thousand tons*	8,013	7,969	*(1%)*
Export terminal's throughput (Ukraine)	*thousand tons*	8,159	7,269	*(11%)*
Grain received in inland silos	*thousand tons*	3,801	4,185	*10%*
Revenue	*US$ million*	4,857	4,535	*(7%)*
EBITDA[2]	*US$ million*	359	237	*(34%)*
EBITDA margin *per ton of grain exported*	*US$*	45	30	*(34%)*

Figure 2.2 – Kernel Infrastructure and Trading Segment [4]

Operational Scope

Kernel's operational footprint extends across various regions, reflecting its commitment to meeting global agricultural demands. The company operates in [list of regions or countries], with a significant presence in each. Its wide-reaching scope ensures the availability of agricultural products in international markets, contributing to global food security.

Sustainability Initiatives

In response to increasing environmental concerns, Kernel has taken substantial steps to incorporate sustainability into its operations. The company actively promotes responsible agricultural practices, emphasizing ecological conservation and resource efficiency. Sustainability initiatives include eco-friendly farming methods, waste reduction, and biodiversity preservation [23].

Competitive Position

In the highly competitive agricultural market, Kernel has carved a niche for itself. A SWOT analysis reveals the company's strengths in efficient automation adoption, diversified product range, and a global presence. However, it also faces challenges such as market volatility and evolving consumer preferences. Kernel's competitive position is marked by its resilience, adaptability, and strategic acumen [24].

Strategic Direction

Kernel's strategic direction aligns with the broader trends in agribusiness, focusing on sustainability, innovation, and automation. The company's vision for the future emphasizes increased automation adoption, improved resource management, and an unwavering commitment to sustainable practices. These strategic elements position Kernel as a forward-thinking and agile enterprise. Strategic Targets of Kernel is represented on Figure 2.3. Operational Highlights of Kernel is represented on Figure 2.4.

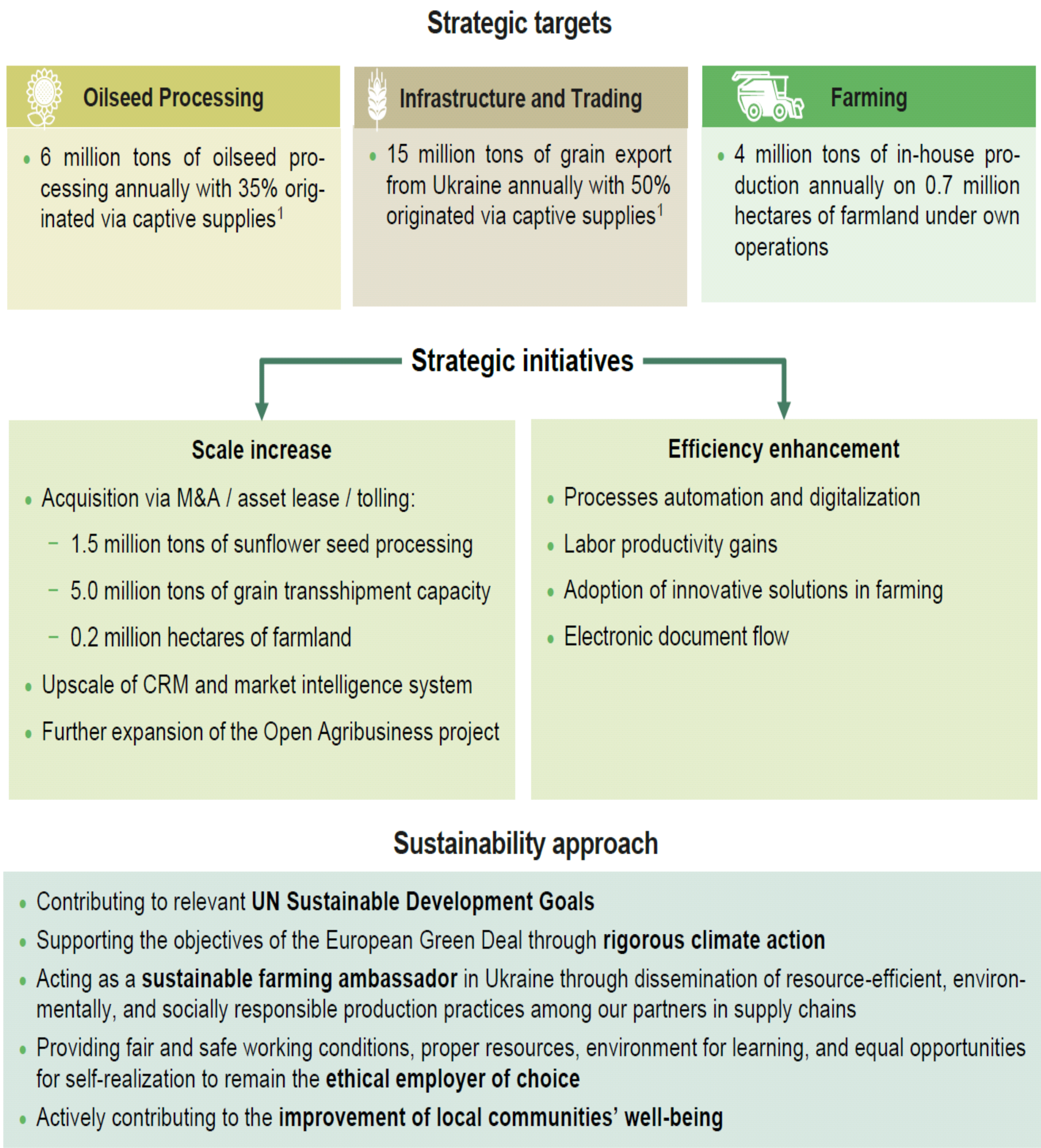


Figure 2.3 – Strategic Targets of Kernel [4]

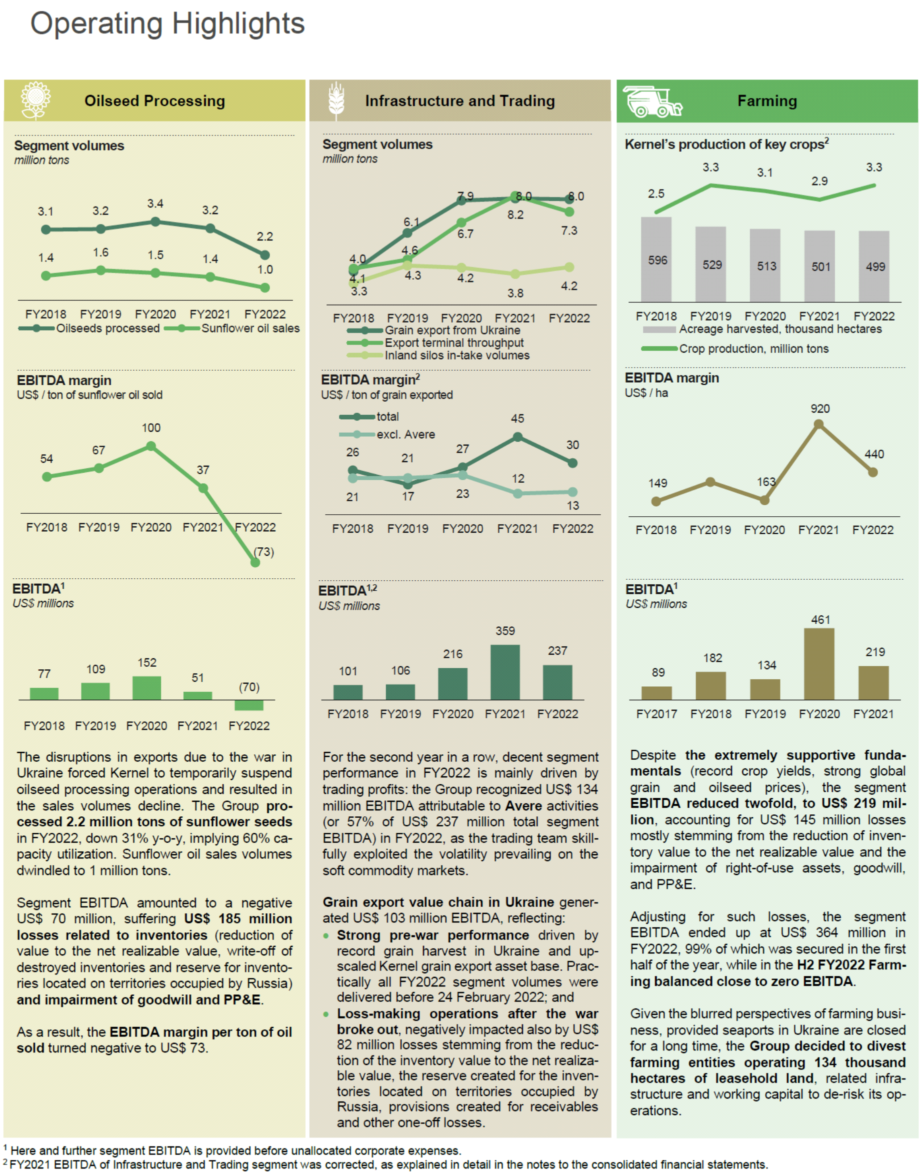


Figure 2.4 – Operational Highlights of Kernel [4]

Research Relevance

Kernel's selection as the focal agricultural enterprise for this research is grounded in its relevance to the study's objectives. As a leading example of automation adoption in agriculture, Kernel's experiences and initiatives serve as a representative case study. The insights gleaned from analysing Kernel's journey are transferable to the broader context of automation's impact on the agricultural industry.

In conclusion, Kernel's comprehensive overview underscores its significance as a pivotal player in the agricultural industry and a prime subject of study for research on automation in agriculture. The company's historical background, expansive operations, technological investments, sustainability efforts, and financial performance collectively paint a portrait of an agricultural enterprise poised for continued success and innovation in the era of automation. Kernel serves as an exemplary case study, illustrating the transformative potential of automation in agriculture [25].

2.2. External and Internal Environmental Analysis and SWOT Analysis of Kernel

External and internal environmental analysis plays a pivotal role in comprehending the dynamics that impact the operations and strategic decisions of an agricultural enterprise like Kernel. This section provides an extensive examination of the factors that constitute the external and internal environments of Kernel, shedding light on how these factors influence the company's operations and strategic direction.

External Environmental Analysis

Kernel operates in a complex macro-environment, and understanding the external forces that affect the company is essential for informed decision-making.

Political Factors

Kernel's operations are subject to political factors such as government policies and regulations, which can significantly influence the agricultural sector. Changes in trade agreements, export/import regulations, or political stability in regions of operation can have direct repercussions on Kernel's supply chain and profitability. Political factors also shape the company's compliance with international standards and its engagement in global trade.

Economic Factors

Economic forces are instrumental in shaping Kernel's business landscape. Fluctuations in currency exchange rates, market conditions, and the economic stability of the regions where Kernel operates impact the company's financial performance. Economic trends, such as shifts in consumer purchasing power, also affect the demand for Kernel's products and services. The company's agility in responding to economic changes is key to maintaining profitability [26].

Social Factors

Kernel is attuned to the ever-evolving social landscape, including consumer preferences, cultural considerations, and demographics. As consumers become increasingly health-conscious and environmentally aware, Kernel must adapt its products and practices to align with shifting societal demands. Understanding these social factors is crucial for product development and marketing strategies, ensuring that Kernel remains relevant in the eyes of its target audience. Social Factors of Kernel represented on Figure 2.5.

Figure 2.5 – Social Factors of Kernel [4]

Technological Factors

The technological environment in which Kernel operates is marked by rapid advancements in agriculture technology. Automation, precision agriculture techniques, and data analytics have transformed the industry. Kernel's investment in these technologies not only streamlines its operational processes but also positions the company as a technology-driven leader in agribusiness. Staying ahead of technological developments and integrating them effectively is paramount for sustaining competitive advantage.

Environmental Factors

Environmental sustainability has become an integral component of Kernel's operational ethos. The company faces increasing pressure to address environmental concerns, from climate change to resource management. Kernel's commitment to sustainable farming practices and ecological conservation is reflected in its eco-friendly initiatives. Understanding and mitigating environmental risks while actively participating in sustainable agriculture practices are central to Kernel's long-term viability [27].

Legal Factors

The legal landscape presents a series of challenges and opportunities for Kernel. Compliance with regulations, adherence to intellectual property rights, and navigating trade restrictions are essential elements of the company's legal framework. Keeping abreast of changing legal requirements and adopting best practices in legal compliance ensures Kernel's operations proceed smoothly and avoid potential legal pitfalls.

Internal Environmental Analysis

An internal analysis provides insights into Kernel's strengths, weaknesses, opportunities, and threats, allowing the company to build on its strengths and address areas of improvement.

Strengths

Kernel possesses several internal strengths that underpin its success. These strengths include a robust technological infrastructure, a diversified product range encompassing grains, oilseeds, and other crops, and a track record of financial stability. These strengths empower Kernel to compete effectively in the agribusiness market. Its technological prowess optimizes efficiency, while its diversified portfolio mitigates risks.

Weaknesses

Like any enterprise, Kernel faces internal challenges. Operational inefficiencies or resource constraints can be considered weaknesses. Identifying and addressing these weaknesses through process optimization and resource allocation strategies is crucial to maintain competitiveness.

Opportunities

Kernel identifies and leverages various opportunities for growth and innovation. Market expansion, embracing technological advancements, and the adoption of automation are internal opportunities that align with the company's vision for sustainable development. By capitalizing on these opportunities, Kernel positions itself for continued success in the agricultural industry [28].

Threats

Internal threats encompass risks that may impact Kernel's performance and stability. Market volatility, intensified competition, and changes in consumer preferences are potential threats. Kernel prepares itself to counter these threats through risk mitigation strategies and contingency planning.

Integration of External and Internal Analysis

The external and internal environmental analyses are intrinsically connected. Kernel's ability to align its internal strengths with external opportunities, mitigate internal weaknesses in the face of external threats, and adapt to changing external factors is indicative of its strategic agility. The integration of these analyses allows Kernel to optimize its performance and competitiveness by making well-informed strategic decisions [29].

In conclusion, the comprehensive external and internal environmental analysis of Kernel provides a nuanced understanding of the complex forces shaping the company's operational landscape. This analysis empowers Kernel to proactively respond to external influences, capitalize on internal strengths, and fortify against potential weaknesses and threats. Kernel's ability to adapt to a dynamic agribusiness environment while maintaining its commitment to sustainability and innovation positions it as a key player in the industry[30].

SWOT Analysis of Kernel. A SWOT analysis is a fundamental tool for assessing the internal and external factors that influence the strategic position and performance of an agricultural enterprise like Kernel. In this analysis, we delve into the strengths, weaknesses, opportunities, and threats faced by Kernel, providing a comprehensive understanding of the company's position in the agribusiness sector.

Strengths

Kernel boasts several internal strengths that form the foundation of its success. One of its standout strengths is its advanced technological infrastructure. The company has strategically invested in automation, precision agriculture techniques, and state-of-the-art processing plants. This technological prowess streamlines operations, optimizes resource utilization, and enhances overall productivity. The adoption of automation, in particular, has positioned Kernel as a technology-driven leader in the agricultural industry.

Additionally, Kernel's strengths encompass a diversified product range, encompassing grains, oilseeds, and other crops. This diversification mitigates risks associated with market fluctuations and ensures a stable revenue stream. Furthermore, the company's robust financial stability is evident in its consistent revenue figures and profitability margin, illustrating its financial competence.

Weaknesses

Despite its strengths, Kernel faces certain internal weaknesses. These include operational inefficiencies that may hinder the company's efficiency and resource constraints that could limit its expansion efforts. Addressing these internal challenges is imperative for maintaining competitiveness.

Kernel recognizes the importance of overcoming these weaknesses through process optimization initiatives and strategic resource allocation. By proactively addressing these shortcomings, the company seeks to bolster its overall performance and operational efficiency.

Opportunities

The analysis also highlights the internal and external opportunities that Kernel can leverage for growth and sustainability. Market expansion is a significant opportunity, especially in regions where demand for agricultural products is increasing. The adoption of technological advancements, including further automation and data analytics, presents an opportunity for Kernel to enhance its efficiency and cost-effectiveness.

Moreover, Kernel is keen on seizing the opportunity to adopt automation more extensively. This not only aligns with industry trends but also optimizes operations, enhances productivity, and reduces operational costs. Such strategic initiatives position the company for continued success in the agricultural sector.

Threats

Both internal and external threats pose potential risks to Kernel's performance and stability. Market volatility, intensified competition, and evolving consumer preferences are examples of threats that could impact the company's market position. Market volatility, in particular, can lead to fluctuating commodity prices, which may affect revenue.

Kernel is well-prepared to counter these threats through risk mitigation strategies and contingency planning. The company's proactive approach involves diversifying its product portfolio, exploring new markets, and investing in sustainable agricultural practices to mitigate potential environmental risks.

Strategic Implications

The SWOT analysis provides valuable insights for Kernel's strategic decision-making. Leveraging its strengths to capitalize on opportunities, such as market expansion and automation adoption, positions the company for growth and competitiveness. Simultaneously, addressing weaknesses and mitigating threats is crucial to ensure long-term sustainability and profitability.

Based on the analysis, it is possible to combine the factors in SWOT matrix for clear understanding. The SWOT matrix is represented in Table 2.1.

Table 2.1 – SWOT matrix of Kernel

Strengths	Weakness
investments in automation, precision agriculture techniques, and state-of-the-art processing plants; streamlines operations; adoption of automation.	operational inefficiencies; resource constraints.
Opportunities	**Threats**
market expansion; adoption of technological advancements; adopt automation more extensively.	market volatility; intensified competition; evolving consumer preferences.

In conclusion, the SWOT analysis of Kernel not only provides a comprehensive understanding of the company's current position but also serves as a strategic compass for shaping its future direction. Kernel's commitment to innovation, sustainability, and the judicious application of technology underscores its readiness to navigate the agricultural landscape with agility and resilience.

2.3. Assessment of Subsystems

Introduction

In the dynamic landscape of agricultural enterprises, the assessment of subsystems plays a pivotal role in ensuring operational efficiency, quality, and sustainability. An agricultural enterprise like Kernel is a multifaceted organization with several critical subsystems that collectively determine its overall performance and competitive advantage. This section embarks on a comprehensive examination of the key subsystems within Kernel, shedding light on how they contribute to the enterprise's success.

Subsystems in Agricultural Enterprise

Kernel, as a prominent agricultural enterprise, comprises several vital subsystems that together orchestrate the intricate dance of its daily operations. These subsystems encompass logistics, supply chain, production, quality control, and sustainability. Understanding each of these subsystems is essential to grasp Kernel's operational complexity and how they synergize for the company's success.

Logistics Subsystem

Within the logistics subsystem, Kernel orchestrates the transportation, storage, and distribution of agricultural products. Logistics is the circulatory system of the enterprise, ensuring that products reach their intended destinations efficiently. Kernel optimizes this subsystem to guarantee timely delivery and cost-effectiveness. This entails meticulous route planning, real-time tracking, and efficient warehousing. The integration of modern technologies, represented on Figure 2.6.

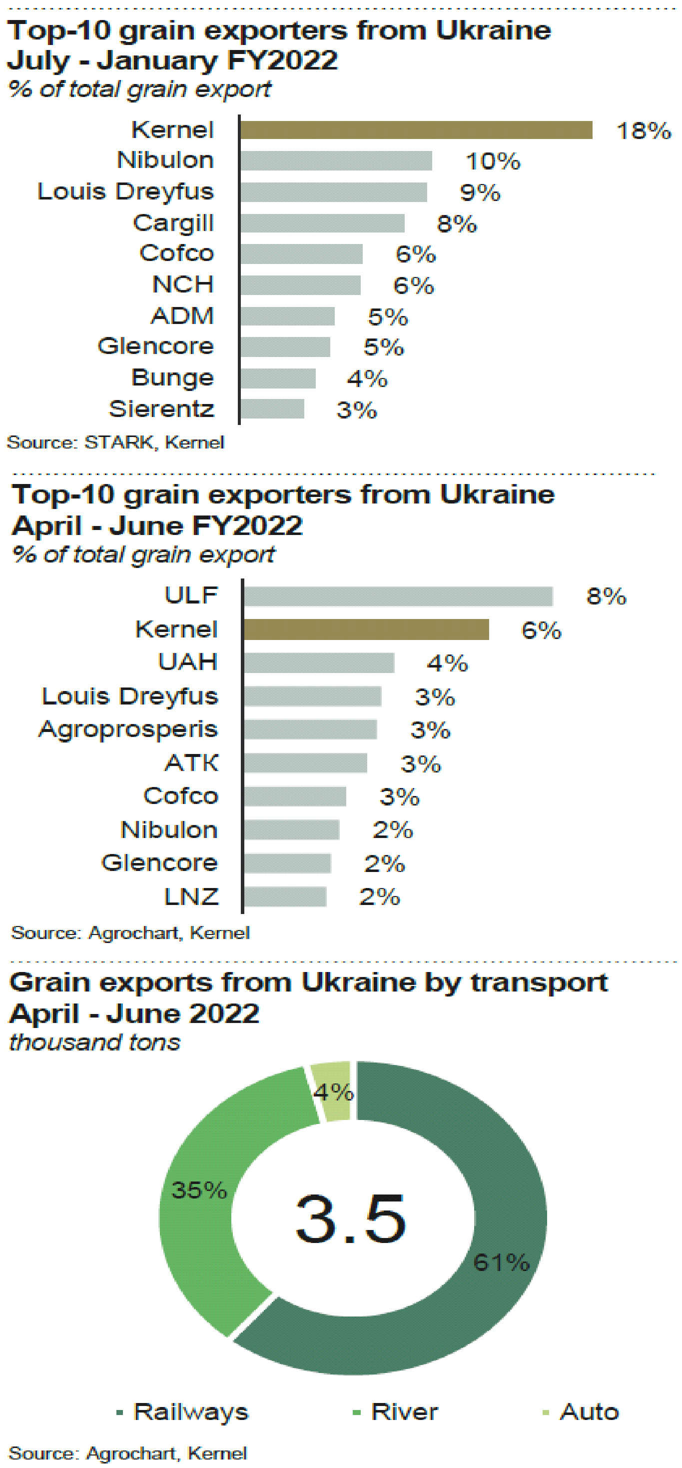


Figure 2.6 – Grain exports from Ukraine [4]

Supply Chain Subsystem

The supply chain subsystem is the lifeline of Kernel's agricultural activities. It encompasses sourcing, procurement, and inventory management. Kernel's supply chain is characterized by its responsiveness to market dynamics, ensuring the timely availability of resources for planting and cultivation. The company's strategic procurement practices involve supplier relationships and timely inventory replenishment. Integration with cutting-edge supply chain management software allows Kernel to maintain a streamlined supply chain, fostering production consistency and customer satisfaction.

Production Subsystem

The production subsystem is at the heart of Kernel's operations. It encompasses activities from planting and cultivation to harvesting. The enterprise's success hinges on maximizing agricultural yields while maintaining operational efficiency and sustainability. Automation and precision agriculture techniques have revolutionized the production subsystem. Kernel deploys advanced machinery, IoT devices, and data analytics to monitor crop health, optimize irrigation, and make real-time adjustments. This not only enhances productivity but also ensures responsible resource management.

Kernel’s EBITDA split represented on Figure 2.7.

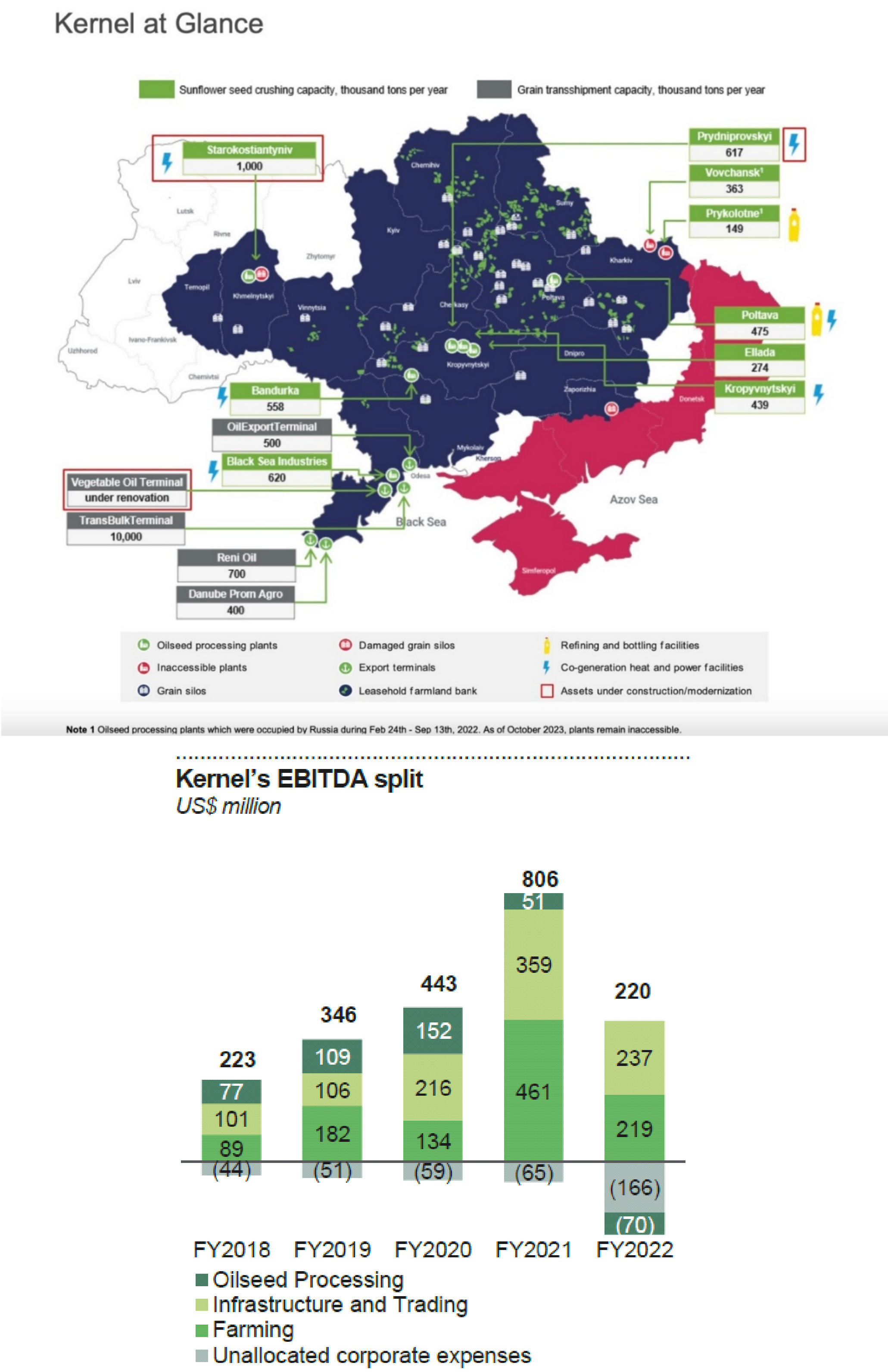


Figure 2.7 – Kernel's EBITDA split [4]

Quality Control Subsystem

Kernel's dedication to quality control is exemplified in its quality control subsystem. This subsystem is responsible for maintaining the high quality of agricultural products, meeting international quality standards, and exceeding customer expectations. Rigorous inspections, testing, and adherence to global quality norms are hallmarks of Kernel's quality control practices. The company's commitment to quality extends from the field to the final product, ensuring consistency and consumer trust.

Sustainability Subsystem

Sustainability is at the core of Kernel's operational ethos. The sustainability subsystem embodies the enterprise's commitment to environmentally responsible agricultural practices. Kernel embraces resource conservation, eco-friendly farming techniques, and a reduced environmental footprint. Sustainability initiatives include responsible land use, water management, and eco-friendly packaging. These practices not only align with societal expectations but also secure Kernel's long-term viability in a world increasingly concerned about environmental issues.

Assessment Metrics

To assess the efficiency and effectiveness of each subsystem, Kernel employs a range of metrics and key performance indicators (KPIs). These metrics may include on-time delivery rates, inventory turnover, crop yield per acre, product quality scores, environmental impact measures, and many others. The collection and analysis of these metrics provide valuable insights into the performance of each subsystem and guide decision-making.

Data Collection and Analysis

Kernel uses a combination of data collection methods, including sensor data from machinery, quality control data from laboratories, and supply chain tracking data. This wealth of data is then analysed through sophisticated data analytics tools, enabling real-time monitoring and predictive insights. Data-driven decision-making enhances the accuracy and effectiveness of the assessment process and empowers Kernel to make informed choices for continuous improvement.

Integration of Subsystems

One of Kernel's notable strengths is the integration and synergy among its subsystems. Well-optimized logistics, supply chain, production, quality control, and sustainability subsystems collectively drive the enterprise's success. These subsystems are interdependent, and their efficient coordination ensures that the right products are delivered at the right time with the right quality and sustainability practices in place. The integration fosters operational excellence and competitive advantage. Kernel's business model represented on Figure 2.8.

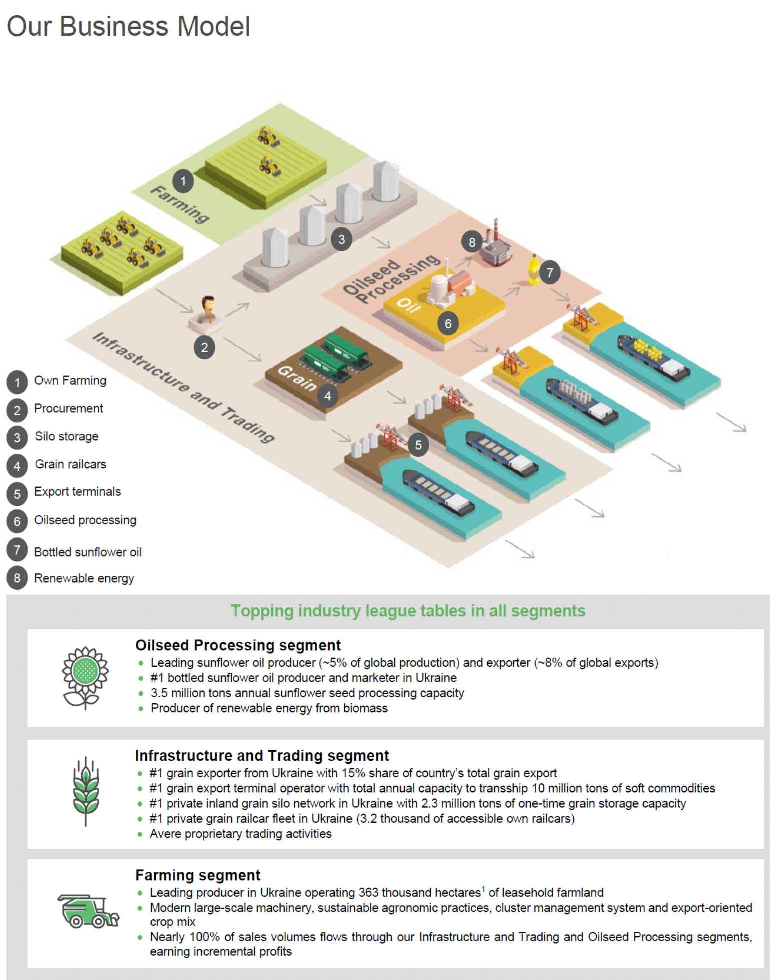


Figure 2.8 – Kernel's business model [4]

In conclusion, the assessment of subsystems within an agricultural enterprise like Kernel is a multifaceted undertaking. It unveils the intricate web of activities that underpin the company's operations, from logistics to sustainability. Understanding and optimizing these subsystems are imperative for ensuring operational efficiency, quality, and sustainability, ultimately positioning Kernel as a leader in the agricultural industry. Continuous assessment and improvement in these subsystems are central to Kernel's commitment to delivering high-quality products and responsible agricultural practices.

2.4. Analysis of Financial Performance and Current Operating Costs

Financial Performance

Kernel's financial performance is robust, exemplifying its competence and stability in the agricultural sector. The company has consistently achieved strong revenue figures, a healthy profitability margin, and a track record of sustainable growth. These financial metrics underline Kernel's position as a key economic contributor in the agricultural industry. Kernel's income statement highlights represented on Figure 2.9.

Income statement highlights
US$ million

	FY2021[1]	FY2022	y-o-y
Revenue	**5,595**	**5,332**	***(5%)***
Net IAS 41 gain	133	13	*(91%)*
Cost of sales	(4,822)	(4,692)	*(3%)*
Gross profit	**906**	**652**	***(28%)***
Other operating income	111	64	*(43%)*
Other operating expenses	-	(45)	*n/a*
Net impairment losses on financial assets	(5)	(33)	*7x*
Loss on impairment of assets	(5)	(317)	*70x*
General, administrative and selling expenses	(318)	(230)	*(28%)*
Operating profit	**689**	**91**	***(87%)***
Finance costs, net	(142)	(119)	*(16%)*
Foreign exchange gain(loss), net	(6)	10	*n/a*
Other (expenses), net	(3)	(25)	*7.7x*
Profit / (loss) before income tax	**538**	**(43)**	***n/a***
Income tax (expenses) / benefit	(32)	3	*n/a*
Profit / (loss) for the period	**506**	**(41)**	***n/a***
Attributable to equity holders of Kernel Holding S.A.	513	(41)	*n/a*
Non-controlling interest	(7)	0.4	*n/a*
EBITDA	**806**	**220**	***(73%)***

Figure 2.9 – Kernel's income statement highlights [4]

In the realm of agricultural enterprises, understanding and effectively managing operating costs are essential to ensuring financial sustainability and long-term success. The analysis of current operating costs is a critical exercise for an agricultural powerhouse like Kernel. This section delves into the intricacies of Kernel's operational cost structure, shedding light on the components, trends, and implications that underpin its financial health.

Operating Costs in Agriculture

Operating costs in agriculture encompass the various expenses that an enterprise like Kernel incurs to maintain day-to-day operations. These costs are multifaceted, ranging from labor and equipment to utilities, land and property maintenance, and beyond. Operating costs are the lifeblood of an agricultural enterprise, fueling its ability to produce, process, and distribute agricultural products efficiently.

Significance of Analysing Operating Costs

Analysing operating costs is more than just an accounting exercise; it's a strategic imperative for Kernel. A comprehensive cost analysis allows the enterprise to unearth potential cost-saving opportunities, fine-tune its operations for efficiency, and make informed decisions about resource allocation. In an industry characterized by fluctuations in commodity prices and market dynamics, the ability to manage operating costs effectively is a cornerstone of financial resilience.

Methodology for Cost Analysis

The methodology employed for the analysis of Kernel's operating costs is rigorous and data-driven. Data is meticulously collected from various sources within the organization, including financial records, expenditure reports, and cost centres. This data is then organized, categorized, and subjected to in-depth analysis. Cutting-edge financial software and data analytics tools play a crucial role in distilling this wealth of information into actionable insights.

Breakdown of Operating Costs

The operating costs within Kernel can be dissected into several distinct categories. Labor costs are a significant component, covering wages and salaries for the workforce, which is essential for planting, cultivation, and harvesting. Machinery and equipment expenses include the maintenance, fuel, and depreciation of the agricultural equipment that powers the enterprise. Utilities, encompassing electricity, water, and fuel, are vital for both processing and transportation. Land and property maintenance costs, such as facility upkeep and land management, are crucial to ensuring the longevity of Kernel's assets.

Trends and Patterns

A critical aspect of the analysis involves identifying trends and patterns within Kernel's operating costs. The agricultural industry is often subject to seasonality, with certain costs fluctuating based on crop cycles. Recognizing these patterns enables Kernel to anticipate and plan for resource allocation. Additionally, the analysis uncovers cost-saving initiatives that the company has implemented, such as energy-efficient practices and optimized machinery maintenance schedules.

Comparison and Benchmarking

Kernel's operating costs are compared to industry benchmarks and competitors. This comparative analysis provides insights into where Kernel excels or faces challenges in cost management. Benchmarking against peers in the agricultural sector serves as a yardstick for evaluating the company's financial efficiency and competitiveness.

Cost Reduction Strategies

In the quest to optimize operating costs, Kernel has employed various cost reduction strategies. These strategies encompass initiatives to reduce labor expenses, enhance equipment maintenance, implement energy-efficient practices, and streamline logistics and transportation. Successful cost-saving measures underline Kernel's commitment to financial prudence.

Impact on Profitability

The analysis underscores the direct impact of operating costs on Kernel's profitability and overall financial performance. By closely monitoring and managing these costs, the company can mitigate financial risks, ensure profitability even in volatile market conditions, and lay the foundation for sustainable growth.

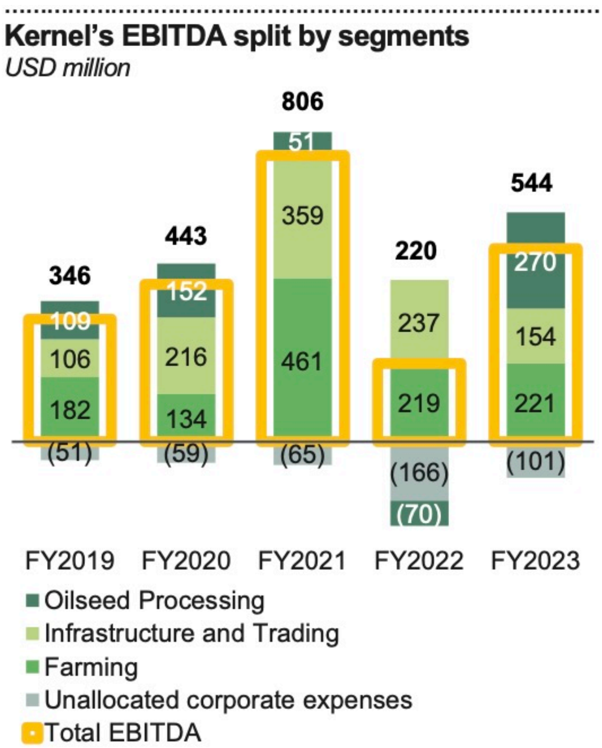
Sustainability and Efficiency

Efficiency and sustainability are intrinsic to Kernel's cost analysis. The enterprise recognizes that cost optimization extends beyond financial considerations. It encompasses resource conservation, eco-friendly practices, and a reduced environmental footprint. The analysis highlights how well-optimized operating costs can contribute to a more sustainable and eco-conscious agricultural enterprise.

Recommendations and Future Planning

Based on the findings of the cost analysis, recommendations are made to enhance cost management. These recommendations may include further investment in energy-efficient technologies, streamlining of labor costs through training and optimization, and exploring new opportunities for cost reduction. Kernel's commitment to ongoing cost analysis and improvement ensures that these recommendations are acted upon to drive financial sustainability.

Analysis of Production and Financial Performance of Kernel represented on Figure 2.10.



Segment results summary

	Revenue, USD million			EBITDA, USD million			Volume, thousand tons[2]			EBITDA margin, USD/t[3]		
	FY2022	FY2023	y-o-y	FY2022	FY2023	y-o-y	FY2022	FY2023	y-o-y	FY2022	FY2023	y-o-y
Oilseed Processing	1,681	1,908	13%	(70)	270	n/a	967	1,139	18%	(73)	237	n/a
Infrastructure and Trading	4,535	2,602	(43%)	237	154	(35%)	7,969	3,705	(54%)	30	42	40%
Farming	635	695	9%	219	221	1%	3,268	1,849	(43%)	440	609	39%
Unallocated corporate expenses				(166)	(101)	(39%)						
Reconciliation	(1,519)	(1,750)	15%									
Total	**5,332**	**3,455**	**(35%)**	**220**	**544**	**2.5x**						

Note 2 Physical grain volumes exported from Ukraine (ex. Avere) for Infrastructure and Trading; harvest of grain and oilseeds in the Farming segment.
Note 3 USD per ton of vegetable oil sold for Oilseed Processing; USD per ton of grain exported (ex. Avere volumes) for Infrastructure and Trading; USD per hectare for Farming.

Figure 2.10 – Analysis of Production and Financial Performance of Kernel [4]

Income statement highlights

The revenue of the Group in FY2023 reduced by 35% y-o-y, to USD 3,455 million, mostly due to lower grain export volumes given the restricted export logistics capabilities.

Driven by a decline in crop prices over the re- porting period, net change in the fair value of biological assets and agricultural pro- duce resulted in a USD 115 million loss in FY2023. This component includes a gain from revaluing crops in the fields to fair value less costs to sell as of 30 June 2023 and expensing the respective gain booked a year earlier. While expensing the previously recognized gain attributable to grain and oilseeds sold, we have not recognized a usual gain for next harvest crops, but, on the contrary, were forced to book losses for the first time in our history, as expected future proceeds from sales of crop 2023 do not allow to cover capitalized expenses related to such crop as of 30 June 2023.

Cost of sales in FY2023 contracted by 42% y-o-y, to USD 2,704 million. While the cost of goods for resale and raw materials used dropped even more, by 53% y-o-y driven by low grain export volumes, shipping and handling costs actually increased by 63% y-o-y, reflecting much more expensive export logistics together with a shift from FOB to CIF sales for the majority of our goods sold.

Other operating income settled at USD 54 million, comprising primarily gains on the sale of hard currency, a part of the reimbursement received under political violence insurance triggered by the war in Ukraine, and stock take. Other operating expenses amounted to USD 35 million, down 22% y-o-y, comprising USD 24 million dispatch and other fines (due to extended waiting times during the loading and unloading of vessels in ports given the in- stability of shipments within the BSGI), and USD 11 million loss on Group’s operations with securities and derivatives.

General, administrative, and selling expenses in FY2023 fell by 11% y-o-y, to USD 205 million, mostly driven by lower payroll and payroll-related costs.

Additionally, the Group booked USD 4 million net reversal of losses in financial assets recognized in previous periods, primarily related to provisions created under the Group's ac- counts receivable.

Kernel also recognized net loss on impairment of assets of USD 15 million in FY2023, as compared to USD 317 million respective loss in the same period of the previous year. This year's result is primarily a combination of USD 30 million reversal of previously created inventory allowances and write-offs (mostly attributable to the Oilseed Processing segment), USD 7 million new allowances and write-offs of inventories, and Group's grain railcars blocked on the territories temporarily occupied by Russia, USD 9 million allowance for VAT refund, and USD 26 million impairment of as- sets held for sale.

Subsequently, operating profit reached USD 439 million, up 4.8x y-o-y.

Despite a decrease in interest-bearing debt balances, finance costs in FY2023 increased by 17% y-o-y, reaching USD 153 million. This rise was primarily due to a substantial growth of LIBOR/SOFR benchmarks used to calculate interest rates. Finance income in FY2023 nearly tripled y-o-y, amounting to USD 31 million, as a result of allocating extra liquidity balances into interest-bearing instruments. The net finance costs remained al- most unchanged y-o-y, standing at USD 122 million for FY2023.

Net foreign exchange gain in the reporting period amounted to USD 63 million, owing to the depreciation of Ukrainian hryvnia against the USD in July 2022 and the respective revaluation of intra-group balances.

Other expenses, net, amounted to USD 12 million, a 53% decline y-o-y, comprising USD 12 million of charity expenses, USD 3 million of fines and penalties, and reflecting also a USD 4 million gain on disposal of subsidiaries (the Group completed disposal of two silos in FY2023 and recognized the respective gain). With the USD 368 million profit before in- come tax generated, the Group recognized corporate income tax expenses of USD 69 million in FY2023 and ended the year with

USD 299 million net profit attributable to shareholders of Kernel Holding S.A. Finally, accounting for USD 241 million of ex- change translation differences occurring due to the depreciation of UAH against USD in July.

Condensed Consolidated Interim Statement of Financial Position

for the three months ended 31 March 2023 (in thousands of US dollars, unless otherwise stated)

	Notes	As of 31 March 2023	As of 31 December 2022	As of 30 June 2022	As of 31 March 2022[1]
Assets					
Current assets					
Cash and cash equivalents	9	880,822	679,223	447,625	372,993
Trade accounts receivable	19	298,933	392,417	142,738	369,436
Prepayments to suppliers	19	185,622	149,567	107,167	106,200
Corporate income tax prepaid		2,001	3,893	12,228	5,363
Taxes recoverable and prepaid		149,490	170,696	204,686	296,286
Inventory	10	636,845	698,862	953,922	1,374,350
Biological assets	11	23,645	66,383	161,911	51,617
Other financial assets	12,19	388,002	166,615	205,811	303,173
Assets classified as held for sale		—	228,227	287,068	—
Total current assets		**2,565,360**	**2,555,883**	**2,523,156**	**2,879,418**
Non-current assets					
Property, plant and equipment	13	1,024,792	1,025,630	1,018,073	1,092,696
Right-of-use assets		203,441	202,338	247,740	358,837
Intangible assets		36,030	35,985	124,198	209,813
Goodwill		68,993	68,993	71,620	81,610
Deferred tax assets		35,932	33,429	41,568	12,076
Non-current financial assets	19	30,622	31,751	52,532	69,004
Other non-current assets		75,377	75,208	106,725	52,963
Total non-current assets		**1,475,187**	**1,473,334**	**1,662,456**	**1,876,999**
Total assets		**4,040,547**	**4,029,217**	**4,185,612**	**4,756,417**
Liabilities and equity					
Current liabilities					
Trade accounts payable	19	140,918	114,570	161,342	233,423
Advances from customers and other current liabilities	19	153,191	155,225	89,200	124,111
Corporate income tax liabilities		15,235	18,488	7,411	58,829
Short-term borrowings	14	909,129	937,012	1,093,087	906,935
Current portion of long-term borrowings	14	—	—	—	28,717
Current portion of lease liabilities		37,295	38,145	39,111	55,835
Current bonds issued	15	596,047	595,782	595,038	—
Interest on bonds issued		17,440	7,612	7,612	17,440
Other financial liabilities	19	69,339	59,820	128,537	196,747
Liabilities associated with assets classified as held for sale		—	94,371	116,848	—
Total current liabilities		**1,938,594**	**2,021,025**	**2,238,186**	**1,622,037**
Non-current liabilities					
Long-term borrowings	14	—	—	—	205,713
Lease liabilities		154,024	148,591	200,441	278,635
Deferred tax liabilities		25,036	6,789	21,893	20,134
Bonds issued	15	—	—	—	594,895
Other non-current liabilities	2, 19	45,248	47,210	38,871	48,130
Total non-current liabilities		**224,308**	**202,590**	**261,205**	**1,147,507**
Equity attributable to Kernel Holding S.A. equity holders					
Issued capital		2,219	2,219	2,219	2,219
Share premium reserve		500,378	500,378	500,378	500,378
Additional paid-in capital		39,944	39,944	39,944	39,944
Treasury shares	2	(96,897)	(96,897)	(96,897)	(96,897)
Revaluation reserve		104,303	104,303	104,303	62,174
Translation reserve		(936,464)	(1,066,942)	(816,490)	(817,051)
Retained earnings		2,261,887	2,317,847	1,949,731	2,290,494
Total equity attributable to Kernel Holding S.A. equity holders		**1,875,370**	**1,800,852**	**1,683,188**	**1,981,261**
Non-controlling interests	4	2,275	4,750	3,033	5,612
Total equity		**1,877,645**	**1,805,602**	**1,686,221**	**1,986,873**
Total liabilities and equity		**4,040,547**	**4,029,217**	**4,185,612**	**4,756,417**
Book value		1,875,370	1,800,852	1,683,188	1,981,261
Number of shares	2	77,429,230	77,429,230	77,429,230	77,429,230
Book value per share (in USD)		24.22	23.26	21.74	25.59
Diluted number of shares		77,429,230	77,429,230	77,429,230	77,429,230
Diluted book value per share (in USD)		24.22	23.26	21.74	25.59

Figure 2.11 – Financial Position [4]

In conclusion, the analysis of current operating costs within Kernel is not just an exercise in financial scrutiny; it's a strategic compass for the enterprise's long-term success. The insights derived from this analysis empower Kernel to make informed decisions, allocate resources effectively, and optimize operations. Operating costs, when managed judiciously, are not just a financial metric; they are a pathway to financial resilience, sustainability, and growth in the ever-evolving landscape of agricultural enterprises.

Following the request of the Board to have an emergency financing option in case the circum- stances in Ukraine require it, the extraordinary general meeting of shareholders held on 23 September 2022 created the authorized share capital and granted authorization to the Board to issue new shares on such terms as the Board sees fit.

In the summer of 2023, while negotiating the third restructuring of the Group's loan portfolio during wartime in Ukraine, the Group's creditors demanded equity support from the Company's shareholders in order to proceed with the restructuring of the loan portfolio. Following several rounds of negotiations, the Group managed to reduce the amount of the demanded equity contribution and agreed to initiate the equity raise of USD 60 million. On 22 August 2023, the Company announced the share offering to qualified investors – existing shareholders of the Company. As a part of the book-building process, shareholders provided their subscription forms which altogether determined (via the mechanism of a Dutch auction) the number of shares to be issued and the issue price in such a way that the Company raised the necessary amount of USD 60 million and completed the requirement of the creditors. Consequently, the Company allotted 216,000,000 shares to several qualified investors (shareholders of the Company) at the issue price of USD 0.2777 per share.

On 1 September 2023, the Board approved the results of the offering and the share capital increase. These shares, all paid up in cash, were issued in the registered form and they will not be admitted to trading on any securities exchange, given the

Company’s pending delisting process. Each share offers its holder a single voting right at the Company's general meeting of shareholders. Additionally, each of these shares carries dividend rights congruent with the existing shares, except for the 6,602,000 shares owned by the Company’s subsidiary Etrecom Investments Limited which does not have voting or dividend rights.

As a result of the share capital increase, the number of Company’s shares issued increased to 300,031,230 shares. These shares collectively represent 293,429,230 voting rights for the Company's General Meeting, factoring in the 6,602,000 shares held by Etrecom Investments Limited, which are devoid of voting rights due to their treasury share nature. The stake of Namsen Limited increased to 91.61% of total shares issued, or 93.67% of shares with voting/dividend rights.

CHAPTER 3
PROJECT PART

3.1. Theoretical Justification of the Project-Based Interventions in Automation in an Agricultural Company: Kernel

3.1.1. Determining Main Directions for Project-Based Interventions in Automation in an Agricultural Company: Kernel

In the ever-evolving landscape of agriculture, staying at the forefront of innovation is imperative for an industry leader like Kernel. Project-based interventions in automation represent a crucial avenue for driving innovation, enhancing operational efficiency, and ensuring sustainable growth. This section delves into the complexities of determining the primary directions for project-based interventions in automation within Kernel.

The Imperative for Project-Based Interventions. The agricultural sector is characterized by continuous transformation, with emerging technologies, changing consumer demands, and environmental considerations shaping its evolution. For Kernel, embracing project-based interventions in automation is not a choice but a strategic necessity. These interventions are the lifeblood of innovation, enabling the company to remain competitive and resilient in a dynamic industry. Automation projects hold the potential to optimize processes, reduce operational costs, and enhance overall productivity [31].

Methodology for Identifying Main Directions. Identifying the main directions for project-based interventions in automation requires a meticulous and data-driven approach. Kernel employs a multifaceted methodology, drawing on extensive data analysis, industry research, and collaborative efforts with experts in automation and agriculture. This methodology ensures that the selected directions are not only technologically sound but also aligned with the company's strategic goals.

Current Automation Landscape. To embark on successful project-based interventions, it is crucial to understand the existing automation landscape within Kernel. The company's current state of automation encompasses a range of technologies and processes, such as precision agriculture techniques, automated processing plants, and advanced logistics solutions. These serve as a foundation for further innovation and improvement [32].

Areas Requiring Automation. Kernel's commitment to innovation extends to various facets of its operations. Several areas within the company's operations present ripe opportunities for automation. These may include:

- Logistics: Streamlining transportation, storage, and distribution of agricultural products.
- Production: Enhancing planting, cultivation, and harvesting through automation.
- Quality Control. Implementing automated inspection and testing processes.
- Sustainability: Leveraging automation for eco-friendly farming practices.

The identification of these areas is based on a thorough assessment of current operations and industry trends.

Technology Assessment. Innovation in automation often hinges on the adoption of cutting-edge technologies. Kernel continuously assesses the latest automation solutions available in the agricultural sector. This assessment includes an exploration of emerging trends in the Internet of Things (IoT), artificial intelligence (AI), robotics, and data analytics. By staying informed about these technologies, Kernel can make informed decisions about the most suitable tools for its projects.

Cost-Benefit Analysis. One of the critical factors in determining the main directions for project-based interventions is the cost-benefit analysis. Each potential automation project is subjected to a rigorous evaluation of its financial feasibility and potential returns on investment. This ensures that projects align with Kernel's financial goals and offer a sustainable path forward.

Sustainability and Environmental Considerations. Kernel's commitment to sustainability is a guiding principle in its project-based interventions. Automation initiatives are evaluated not only for their financial viability but also for their environmental impact. This consideration includes the reduction of resource consumption, eco-friendly practices, and minimizing the environmental footprint of automation projects [33].

Risk Assessment. Recognizing potential risks and challenges is a vital aspect of project planning. Kernel conducts a comprehensive risk assessment for each automation project. This assessment aims to identify potential obstacles and develop risk mitigation strategies to ensure the successful implementation of projects.

Integration and Scalability. Incorporating new automation solutions with existing systems and ensuring scalability for future growth is paramount. Kernel's automation projects are designed to seamlessly integrate with current operations, allowing for a smooth transition. Scalability is a core principle, enabling the company to adapt to changing market dynamics and expansion.

Prioritization and Roadmap. After identifying the potential project-based interventions, Kernel prioritizes them based on their potential impact and feasibility. These priorities form the basis for the development of a project roadmap that outlines the phased implementation of automation projects. This roadmap ensures that projects are executed systematically and in alignment with the company's strategic vision.

In conclusion, the process of determining the main directions for project-based interventions in automation within Kernel is a dynamic and multifaceted endeavor. It encompasses a careful evaluation of current automation capabilities, identification of areas requiring automation, technology assessments, cost-benefit analyses, and a commitment to sustainability. The ultimate goal is to foster innovation, competitiveness, and sustainability within the agricultural industry, positioning Kernel as a leader in the ever-advancing world of automation in agriculture.

3.1.2. Justification of Proposed Projects of Automation in an Agricultural Company: Kernel

Significance of Project Justification. The significance of justifying proposed projects of automation cannot be overstated. In the ever-evolving landscape of agriculture, it ensures that resources are channeled into initiatives that are not only promising but also perfectly aligned with Kernel's strategic vision. Justification serves as the gatekeeper, allowing only the most impactful and feasible projects to move forward.

Alignment with Company Objectives. At the heart of project justification lies the alignment with Kernel's overarching objectives. Each proposed automation project must be scrutinized to ensure that it is in harmony with the company's mission, vision, and strategic goals. This alignment is paramount in ensuring that projects contribute to the realization of Kernel's long-term aspirations.

Technological Feasibility. Before a project can be greenlit, its technological feasibility must be rigorously evaluated. Kernel must assess the readiness of automation technologies and their compatibility with existing systems. This entails a detailed examination of the hardware, software, and infrastructure requirements, as well as the availability of technical expertise to implement and manage these solutions.

Economic Viability. One of the central pillars of project justification is the economic viability of proposed projects. Each project must undergo a comprehensive cost-benefit analysis to determine its potential return on investment. This includes considerations such as initial implementation costs, ongoing operational expenses, expected cost savings, payback periods, and net gains over time.

Operational Efficiency. Automation projects are not just about embracing the latest technologies; they must significantly enhance operational efficiency within Kernel. The justification process evaluates how each project impacts various aspects of operations, from production and logistics to quality control. The goal is to identify projects that streamline processes, reduce lead times, and improve overall productivity.

Competitive Advantage. In an industry as competitive as agriculture, securing a competitive advantage is paramount. The justification process analyzes how proposed automation projects can set Kernel apart from its competitors. It assesses whether the projects provide unique capabilities, improve product quality, or enable Kernel to respond more rapidly to market changes [34].

Environmental Sustainability. Kernel's commitment to environmental sustainability is a guiding principle in the justification process. Each proposed project is scrutinized to determine its environmental impact. The focus is on reducing resource consumption, minimizing waste, and promoting eco-friendly practices. This aligns with Kernel's sustainability goals and its responsibility as a steward of the environment.

Risk Mitigation Strategies. Recognizing that no project is without its risks, the justification process includes the identification of potential challenges and uncertainties. For each project, risk mitigation strategies are developed to address these challenges. The aim is to ensure that potential obstacles do not hinder project success.

Long-Term Impact. The true value of proposed projects extends beyond immediate gains. The justification process considers the long-term impact of these projects on Kernel's growth and sustainability. It assesses how the projects position the company for success in the years to come, recognizing that decisions made today shape the future.

Alignment with Industry Trends. In a rapidly evolving agricultural landscape, being in sync with industry trends is vital. The justification process analyzes how proposed projects align with current and emerging industry trends. It considers whether these projects position Kernel as an innovator, capable of adapting to changing market dynamics.

Stakeholder Involvement. Kernel recognizes the importance of involving stakeholders in the justification process. This includes seeking insights and feedback from employees, management, investors, and industry experts. Their involvement ensures that the decision-making process is well-informed and that diverse perspectives are considered.

Recommendations. In the culmination of the justification process, the findings for each proposed project are summarized. Recommendations are provided, guiding the prioritization and implementation of projects. These recommendations are the culmination of rigorous analysis and evaluation, ensuring that only the most promising projects move forward.

In conclusion, the process of justifying proposed projects of automation within Kernel is a comprehensive and meticulous journey. It is a testament to the company's commitment to informed decision-making, ensuring that resources are allocated to projects that not only hold promise but also align with strategic goals. Justification is the cornerstone of Kernel's journey toward innovation, competitiveness, and sustainability in the agricultural industry.

3.1.3. Economic Feasibility and ROI Calculations of Proposed Projects of Automation

In the dynamic realm of agricultural automation, making sound investment decisions is paramount, and it hinges on the economic feasibility and Return on Investment (ROI) calculations. This section delves into the heart of financial assessments for proposed automation projects within Kernel, shedding light on the rigorous evaluation that guides resource allocation and strategic choices.

Economic Feasibility Assessment. Evaluating the economic feasibility of proposed projects is a meticulous process that forms the cornerstone of informed decision-making at Kernel. This assessment involves a comprehensive framework and criteria aimed at scrutinizing every facet of a project. It entails a rigorous analysis of costs, benefits, and risks, all designed to paint a comprehensive picture of a project's viability.

Cost Analysis. Understanding the economic feasibility of each proposed automation project starts with a granular cost analysis. This includes a detailed breakdown of all associated costs, spanning initial implementation costs and ongoing operational expenses. Kernel places utmost importance on accurately estimating every cost component to prevent budgetary surprises down the road.

Benefit Analysis. Equally important is the benefit analysis, which delves into the anticipated gains of each proposed project. These benefits encompass a wide spectrum, ranging from increased productivity, reduced labor costs, and improved product quality to enhanced operational efficiency. It's here that the promise of automation truly shines, as Kernel envisions a future where these benefits translate into tangible advantages.

Return on Investment (ROI) Calculation. ROI is the linchpin of financial assessment. It provides a clear, quantitative measure of a project's financial attractiveness. The ROI calculation method, involving the net gain relative to the project's cost, is robustly executed. A formula and practical examples are employed to illustrate how ROI is determined for each project, offering a crystal-clear perspective on the potential returns [35].

Payback Period Assessment. The payback period is a concept that holds special significance. It denotes the time it takes for an investment to recoup its initial costs through the net returns generated. Kernel is acutely aware of the importance of assessing when an investment will start yielding profits. This period, critical for financial planning, is calculated for each proposed project.

Net Present Value (NPV) Analysis. Going beyond ROI, the Net Present Value (NPV) analysis places a project's current value in monetary terms. It enables Kernel to understand the present worth of future cash flows associated with each project. NPV calculations, a vital tool in financial decision-making, provide valuable insights. They are carried out meticulously, offering clear indications of whether a project is financially favourable.

Internal Rate of Return (IRR) Calculation. The IRR is a metric that complements ROI, offering additional insight into the potential return on investment. It measures the project's rate of return and is an important indicator of a project's financial attractiveness. Kernel applies the IRR calculation method and interprets the results, enabling a comprehensive understanding of project viability.

Sensitivity Analysis. In the world of financial assessments, acknowledging the inherent uncertainties is a must. Kernel recognizes that variables and assumptions can change, impacting project viability. Therefore, sensitivity analyses are conducted to gauge how variations in these factors affect a project's financial feasibility. This proactive approach allows Kernel to be prepared for different scenarios.

Risk Mitigation Strategies. Identifying potential risks and uncertainties is an integral part of the economic feasibility assessment. Recognizing that no project is without its challenges, Kernel outlines risk mitigation strategies to address these potential obstacles. By addressing and managing risks proactively, Kernel enhances the likelihood of achieving projected ROI.

Comparison and Prioritization. With economic feasibility and ROI calculations for all proposed projects in hand, the next step involves comparison and prioritization. Kernel conducts a thorough analysis to compare the financial attractiveness of each project. This process helps in prioritizing projects based on their potential to deliver the highest ROI and align with the company's strategic goals.

In conclusion, the economic feasibility and ROI calculations represent the financial compass guiding Kernel's journey into the realm of agricultural automation. They serve as the litmus test for potential projects, ensuring that resources are allocated to initiatives that not only promise financial returns but also align with the company's overarching goals. In a sector where sound financial decisions are pivotal, these calculations are the bedrock of Kernel's pursuit of innovation, growth, and sustainability.

3.2. Introduction to Project Automated Hydroponic Lettuce Cultivation Using Controllers

3.2.1. Brief summary of a project Automated Hydroponic Lettuce Cultivation Using Controllers.

The goal of this project is to build a greenhouse with automated supply of water and fertilizers. As well as automation of all possible processes associated with the replacement of human activity. We will show our Work-Breakdown Structure of this project, PERT analysis, define critical activities of our project. The end result of our project is a fully automated and improved greenhouse with the launch of the first harvest batch

In the ever-evolving landscape of agriculture, the infusion of automation emerges as a transformative force. This project stands at the forefront, harnessing the potential of controllers to revolutionize hydroponic lettuce cultivation. By introducing automated systems that intricately regulate environmental variables and nutrient delivery, the initiative aims to elevate the efficiency and yield of lettuce cultivation. Lettuce, with its versatility and rapid growth, serves as an ideal canvas for implementing and assessing advanced automated hydroponic systems [36].

Let's start with the fact that of all Kernel's problems, constant modernization, probably the largest and most relevant. This way we get the fastest return on investment and increase efficiency in the best possible future updates. According to the statement: modernization of the enterprise means not only purchase of new modules, and a whole program of complex actions among which will have many points and sub-points, such as introduction hybrid greenhouse installations (which will have both soil and soil-free cultivation) implementation of a special digital application to simplify bureaucracy, restoration of own fertilizer production enterprises.

That is why we chose this project. We are modernizing one greenhouse and, based on its productivity and costs used in the KERNEL project, will decide the fate of the remaining greenhouse complexes. Our project is a project, not a routine, because it has an end goal, a deadline.

Our project would be a chore for developed enterprises, for example in Europe or Asia, since there is constant modernization, it is easier for strong enterprises to gradually invest money and improve every day. Today there is a problem with the supply of fertilizers as well as with the payment and search for labour for specialists due to the social factor.

Our task is to fix this - the solution is a fully automated greenhouse with its own microclimate; we will analyse it price, quantity we need, and how its implementation will affect increase in turnover and final price for the product.

Modernization requires large initial investments costs, but will bring benefits in the long run. The combination of these only two factors should make our project worthwhile.

3.2.2. Theoretical part of the project

Hydroponics is a type of horticulture and a subset of hydroculture which involves growing plants, usually crops or medicinal plants, without soil, by using water based mineral nutrient solutions. Terrestrial or aquatic plants may grow with their roots exposed to the nutritious liquid or the roots may be mechanically supported by an inert medium such as perlite, gravel, or other substrates.

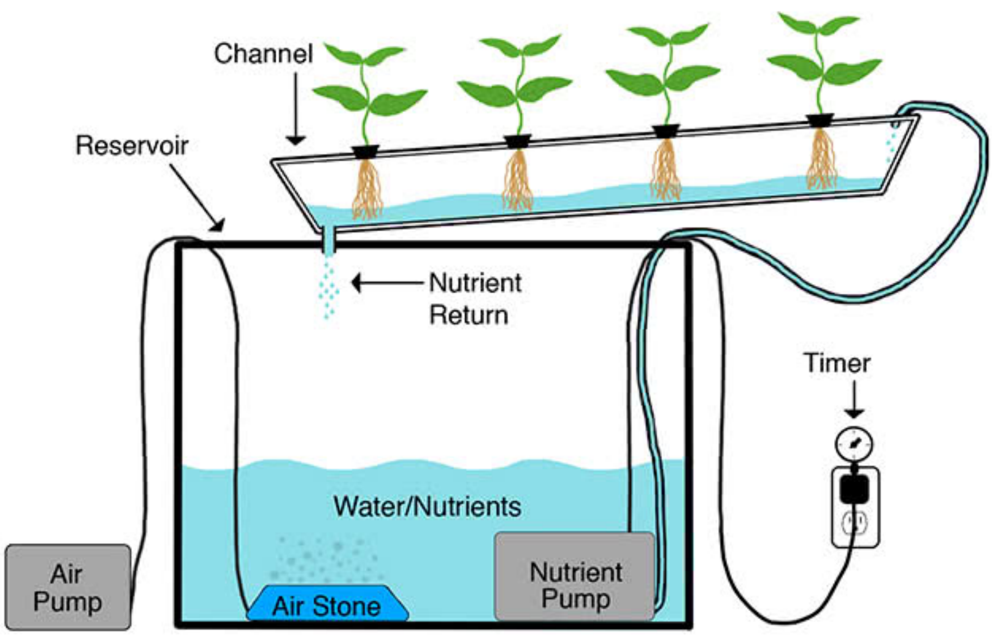


Figure 3.1 Hydroponic system

Despite inert media, roots can cause changes of the rhizosphere pH and root exudates can affect rhizosphere biology and physiological balance of the nutrient solution when secondary metabolites are produced in plants. Transgenic plants grown hydroponically allow the release of pharmaceutical proteins as part of the root exudate into the hydroponic medium.

The nutrients used in hydroponic systems can come from many different organic or inorganic sources, including fish excrement, duck manure, purchased chemical fertilizers, or artificial standard or hybrid nutrient solutions. In contrast to field cultivation, plants are commonly grown hydroponically in a greenhouse or contained environment on inert media, adapted to the controlled-environment agriculture (CEA) process. Plants commonly grown hydroponically include tomatoes, peppers, cucumbers, strawberries, lettuces, and cannabis, usually for commercial use, as well as *Arabidopsis thaliana*, which serves as a model organism in plant science and genetics [37].

Hydroponics offers many advantages, notably a decrease in water usage in agriculture. To grow 1 kilogram (2.2 lb) of tomatoes using intensive farming methods requires 214 liters (47 imp gal; 57 U.S. gal) of water;[10]using hydroponics, 70 liters (15 imp gal; 18 U.S. gal); and only 20 liters (4.4 imp gal; 5.3 U.S. gal) using aeroponics.

Hydroponic cultures lead to highest biomass and protein production compared to other growth substrates, of plants cultivated in the same environmental conditions and supplied with equal amounts of nutrients.[12]

Since hydroponic growing takes much less water and nutrients to grow produce, and climate change threatens agricultural yields, it could be possible in the future for people in harsh environments with little accessible water to hydroponically grow their own plant-based food.

Hydroponics is not only used on earth, but has also proven itself in plant production experiments in space.

The Impact of Hydroponics on the Food Market: Transforming Agriculture for a Sustainable Future. Hydroponics, a revolutionary method of cultivating plants without soil, has emerged as a transformative force in agriculture. This topic explores the profound impact of hydroponics on the food market, highlighting its contributions to sustainability, efficiency, and the changing dynamics of how we produce and consume food.

Revolutionizing Crop Production. Hydroponics has revolutionized traditional crop production methods by providing an alternative to conventional soil-based agriculture. This soilless technique involves cultivating plants in nutrient-rich water solutions, enabling precise control over essential factors such as nutrient levels, pH balance, and environmental conditions. This meticulous control results in accelerated plant growth, increased yields, and a consistent supply of fresh produce.

Year-Round Availability. One of the key impacts of hydroponics on the food market is the ability to defy seasonal constraints. Hydroponic systems allow for year-round cultivation, ensuring a continuous supply of fresh fruits, vegetables, and herbs irrespective of external weather conditions. This has significantly altered consumer expectations, with a growing demand for a consistent and diverse array of produce throughout the year [38].

Resource Efficiency and Sustainability. Hydroponics represents a paradigm shift towards resource-efficient and sustainable agriculture. By delivering nutrients directly to plant roots, water usage is minimized compared to traditional farming methods. Additionally, hydroponic systems reduce the reliance on arable land, making them suitable for urban environments. The controlled settings of hydroponics also mitigate the need for pesticides, contributing to environmentally friendly and ecologically sustainable food production.

Quality and Nutritional Value. The impact of hydroponics extends to the quality and nutritional value of crops. The controlled environments prevent soil-borne diseases, ensuring healthier plants. The precise management of nutrients leads to crops with enhanced flavour, texture, and nutritional profiles. As a result, hydroponically grown produce often commands a premium in the market due to its superior quality.

Localizing Food Production. Hydroponics facilitates localized food production, aligning with the growing trend of supporting local and sustainable agriculture. Vertical farms, rooftop gardens, and indoor hydroponic setups allow urban areas to produce their own fresh produce, reducing the carbon footprint associated with long-distance transportation. This localized approach to food production resonates with consumers seeking environmentally conscious choices.

Challenges and Future Directions. While hydroponics has brought about remarkable changes, challenges such as initial setup costs, energy consumption, and the need for specialized knowledge persist. Ongoing research and technological advancements are addressing these challenges, paving the way for wider adoption and integration of hydroponics into mainstream agriculture.

In conclusion, the impact of hydroponics on the food market is multifaceted, ranging from increased efficiency and sustainability to the transformation of consumer expectations. As the world grapples with the need for resilient and sustainable food systems, hydroponics stands as a beacon of innovation, reshaping the agricultural landscape and influencing how we grow, distribute, and consume food.

3.2.3. What are the technologies used in hydroponics?

1. Data Loggers: Data loggers are used to record and store the data collected by sensors over time. They can be connected to multiple sensors and are helpful in tracking environmental trends and changes.

2. Automated Control Systems: These systems use the data from sensors and data loggers to control environmental factors automatically. They can adjust parameters like temperature, humidity, and light intensity based on predefined setpoints or user-defined parameters.

3. Climate Controllers: Climate controllers are specialized systems that integrate sensors, data loggers, and automated control systems. They allow for comprehensive control over multiple environmental factors simultaneously.

4. HVAC Systems: Heating, ventilation, and air conditioning (HVAC) systems are crucial for maintaining the desired temperature and humidity levels in the hydroponic facility. They can be automated or manually controlled.

5. Light Control Systems: In indoor hydroponics setups, light control systems are used to manage artificial lighting. They can adjust light intensity and duration to mimic natural daylight conditions.

6. CO2 Injection Systems: CO2 is essential for photosynthesis, and CO2 injection systems are used to maintain optimal CO2 levels in the growing environment.

7. Environmental Monitoring Software: This software collects and analyzes data from various sensors and devices, giving growers real-time insights into the hydroponic system’s performance. It can also send alerts and notifications when environmental conditions deviate from the desired range.

8. Remote Monitoring and Control Systems: These systems enable growers to remotely monitor and control their hydroponic setup using smartphones, tablets, or computers. This offers flexibility and convenience in managing the system.

9. Water Quality Monitoring Tools: Monitoring tools such as pH meters, electrical conductivity (EC) meters, and nutrient level sensors help ensure the nutrient solution's composition is appropriate for plant growth.

10. Humidifiers and Dehumidifiers: Humidifiers increase humidity levels, while dehumidifiers reduce excess humidity in the growing environment. They are used to maintain optimal humidity levels for plant growth.

11. Light Sensors and Timers: Light sensors can detect natural light levels, and timers control the duration of artificial lighting in the hydroponic system.

Hydroponic farmers can achieve precise control over environmental factors by integrating these tools and machines.

Using and implementing technology in the formulation and delivery of nutrient solutions in hydroponics farming can significantly improve the accuracy, efficiency, and effectiveness of nutrient management.

Hydroponics Market Analysis. The hydroponics market size is expected to grow from US$4.69 billion in 2023 to US$6.83 billion by 2028 at a CAGR of 7.80% during the forecast period (2023-2028).

Hydroponic farming not only helps protect the environment, but also helps produce higher crop yields compared to open-field production. Additionally, increased health awareness among consumers has created higher demand, leading to increased adoption of hydroponic production methods [39].

Increasing pressure on global arable land, increased demand for food and a shift in the global diet towards consumption of fresh fruits and vegetables are factors contributing to the increase in the area under hydroponics. In countries where climate conditions are unfavorable for open-land farming, hydroponics provides a sustainable option for growing fresh produce for markets.

To achieve food self-sufficiency, hydroponics provides an effective solution to food security as the technology makes efficient use of space and can be used even by landless urban and rural dwellers. According to a USDA/ERS report, hydroponic tomato imports from countries such as Canada, Mexico and the Netherlands have increased dramatically and now account for a significant share of all fresh tomato imports from the United States.

Leafy vegetables and microgreens have traditionally been the most cultivated hydroponic crops. However, hydroponic acreage is increasing in crops exotic to warmer climates, such as cherry tomatoes, lettuce, microgreens and a wide range of other cool-season crops [40].

Hydroponics is an environmentally friendly and profitable technology in developed regions such as North America. It has been promoted by various governments and non-governmental organizations due to its benefits in terms of food security. The need for food supply against explosive population growth by 2050 has catalyzed the growth of the hydroponics market. Additionally, with the increasing success associated with the commercial hydroponics industry and the increasing difficulty of growing crops in soil, the hydroponics market is expanding exponentially.

Higher consumption of salads and exotic vegetables. The demand for exotic fruits and vegetables is constantly growing at a higher rate due to the increased purchasing power of consumers. The cost of these exotic products is high as most of these products are imported and thus several research institutes and universities are focusing on creating more simplified hydroponic systems to speed up the production of exotic fruits and vegetables and meet the growing demand.

Moreover, increasing consumer awareness about consuming fresh vegetables can also boost the market in the future. Demand for exotic vegetables such as red and yellow capsicums and red lettuce from grocery and retail chains such as Burger King and KFC is expected to boost sales during the forecast period.

Moreover, with rapid urbanization, the demand for hydroponically grown vegetables and crops is increasing from several industries such as hotels, restaurants, fast food chains, railway catering, NGOs and defence, which encourages farmers to grow produce using hydroponic systems [41].

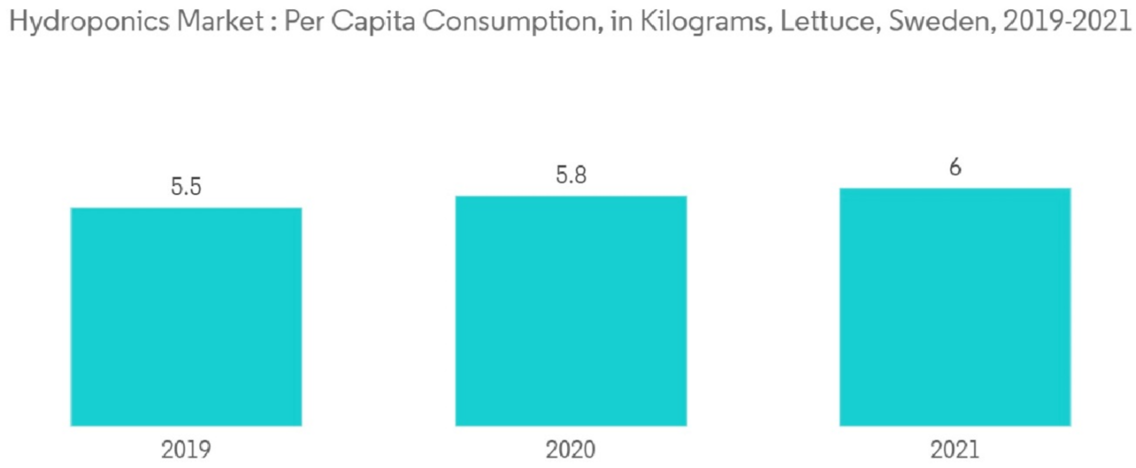


Figure 3.2 – Hydroponic Market

Hydroponic production has gained popularity among commercial vegetable growers because it is an effective method of controlling costs and controlling disease and pests rather than a labor-intensive method of managing large production areas. Since hydroponics eliminates the need for soil fumigants and can increase the yield of popular vegetables, farmers in the region are expected to adopt hydroponics as a popular growing method. The growing adoption of hydroponics as a growing method is expected to drive the growth of the market [42].

Development of the hydroponics market. October 2022 GrowGeneration Corp (GRWG) opened a 9,000 square foot store in Richmond, its first hydroponics store in Virginia. GRWG plans to expand its presence in the state to capitalize on the emerging hydroponics market. The company also signed two new leases for stores in Mount Holly, New Jersey, and Hazelwood, Missouri, which are expected to open by the end of 2022. With this, GRWG expanded its presence to 17 states[43].

July 2022 Bustanica opened the doors of the world's largest hydroponic farm with an investment of US$40 million. The facility is the first vertical farm for Emirates Crop One, a joint venture between Emirates Flight Catering (EKFC), one of the world's largest catering operations serving more than 100 airlines, and Crop One, a leader in high-tech indoor vertical farming [44].

February 2022 Silal, Abu Dhabi's leading fresh produce and agri-tech company, and AeroFarms signed a Memorandum of Understanding (MoU) to establish long-term collaboration on research and development, including the transfer of knowledge and technology of advanced farming systems to local farmers[45].

3.3. Project-Based Interventions in Automation in an Agricultural Company: Automated Hydroponic Lettuce Cultivation Using Controllers

Current project about the automatization in the agrarian sector of indoor growing be hydroponics methods. For the cultural of growing was taken the lettuce plant. To the measure the effectiveness of automatization on implementation was taken a limited close area 1 hectare m^2.

First of all, for the indoor growing needs to copy the climate and nature influents: water, CO_2, fertilizers, wind, sunshine, air humidity, oxygen. [46].

To copy all this factors in the indoor needs the next devises:

1.Hydroponics setup with air pump

2. Water supply pump

3. The controller of ph,(potential of hydrogen" (or "power of hydrogen"), temperature of water, ppm (Parts Per Million It tells us the density of a given substance dissolved in water. Examples include free chlorine, calcium hardness, and total alkalinity.)

4.Boxex with fertilizers and water

5. Led lamps

6. Hood

7. Air supply fan

8. Air filter

9. Fan for air circulation

10. Timer

11. Humidifier and dehumidifier

12 The Balloon with CO_2

From the logistics point in the automatization subject the most interesting prosses -it is the process of delivery the solution (water + fertilizers) by pipes. On this example, we will look the example of automatization [47].

In the hydroponics setup we need the solution a certain level of ph and ppm. For example, take the vegetation period of growing – it is ph 5.5-6.5, ppm by 600-800. To make it and support setup we need controller. First of all it is program. We put the level of PH from the minimum of 5.5 to maximum of 6.5. To control of the level in tank with solution it will use separate two pams that will be connected to separate two tanks. In the first tank will be substance №1 named «PH UP» that make Ph level grow up. In the second tank will be substance №2 named «PH DOWN» that make Ph level grow down. When the device for measuring the PH level in a solution with fertilizers. Transmits information that there is a decrease in the PH level, then the program on the controller decides to take the intended solution from the first tank to increase the ph level. For this purpose, starting the first pump that connected to the tank with solution for hanging the ph level at one end and distils it into a solution with water and fertilizers at the other end [48].

Figure 3.3 – Integrated greenhouse automatic control system "SMART HYDRA" in process

Figure 3.4 –Integrated greenhouse automatic control system "SMART HYDRA"

The complex provides automatic and manual settings: - turning on/off various devices for a given period of time, including smooth sunrises and sunsets of lighting systems, monitoring and control of temperature and humidity, analysis and adjustment of CO2 with the construction of daily/weekly/monthly charts and much more.

Advantages:

- control of pumps and irrigation valves by time or water flow, in any combination;
- control of fertilizer consumption during irrigation;
- automatic preparation of a nutrient solution from several components in a given proportion;

- unlimited number of recipes for preparing nutrient solutions;
- management of individual irrigation recipes for each crop/irrigation area;
- automatic correction of pH and EC of water;
- climate control (heating and cooling to maintain the set temperature/humidity);
- control of lighting lamps in the greenhouse (on/off according to a given schedule, including smooth sunrises and sunsets, simulating the natural environment);
- control of CO2 supply in the greenhouse;
- control of solution temperature for hydroponics and aeroponics;
- notification of accidents via notification on mobile phone.

"SMART HYDRA" creates an ideal microclimate, correct and balanced diet and lighting for plants.

Example of the cost of multi-row industrial greenhouses

Production: Holland

Walls and roof: glass

Area: 7 hectares: 2 greenhouses of 2.5 hectares each

Grown: tomatoes

Price: 4 million euros on FCA terms

Additional costs: VAT, customs duty, local construction work (installation and connection to utility networks)

Design, approvals and construction

As a result, one hectare of industrial greenhouses costs from 75 million. hryvnia (as of March 2021).

Work Breakddown Structure. We begin pur practical work with thr Work Breakdown Structure of modernization of greenhouse to clearly state our goal, major tasks and subtasks [49].

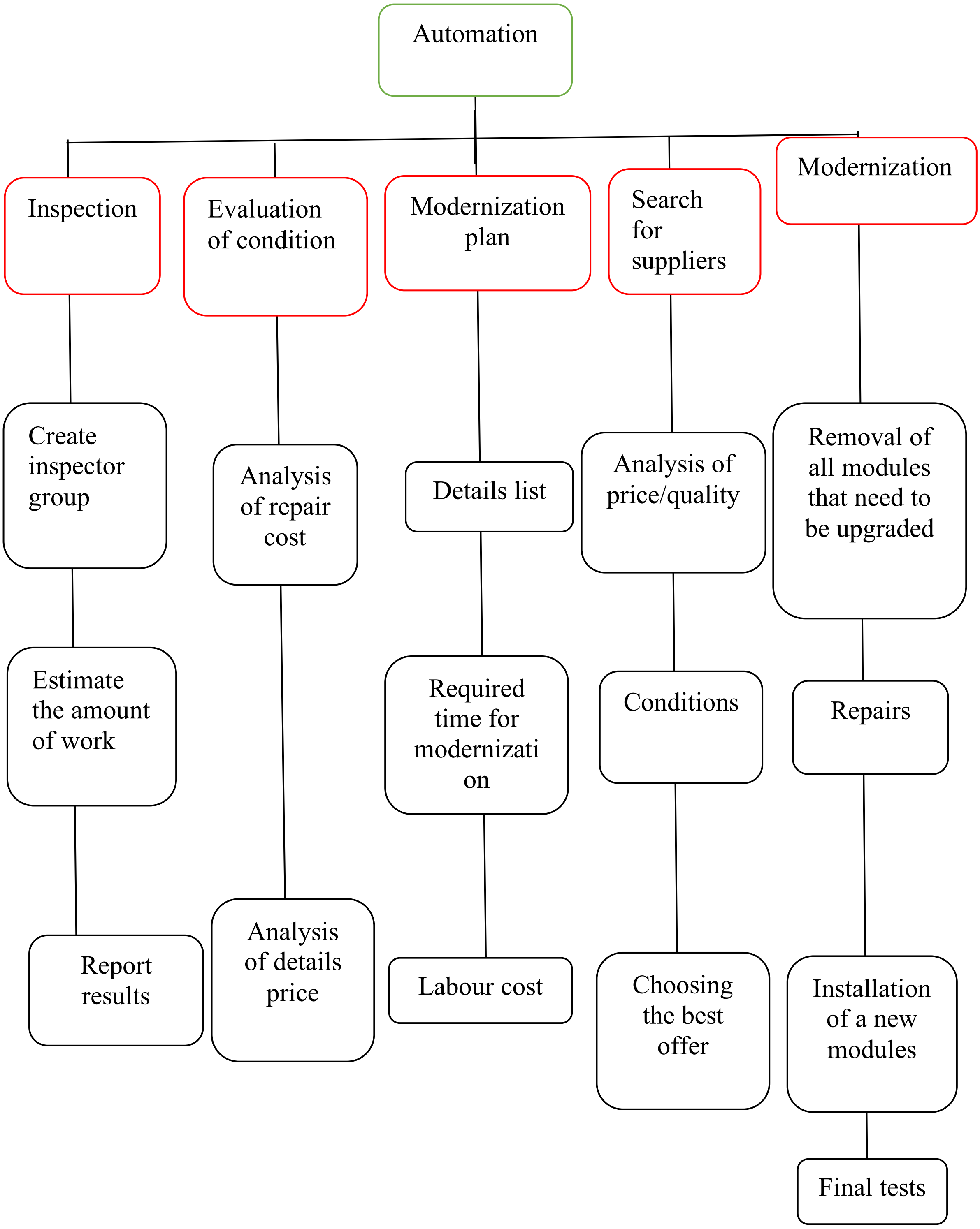


Figure 3.5 – Work Breakdown structure of greenhouse automation

Automation – Our ultimate goal is to automate one Kernel greenhouse to a higher level.

1. Inspection - first you need to inspect the greenhouse in order to know exactly what is already there and what will have to be modernized.

A. Creation of an inspection team - for this we are creating an inspection team of 3 employees (one electrician, one agronomist and one installation engineer) who are familiar with the greenhouse and know all the ins and outs.

b. Inspection of the greenhouse - the inspection itself. Our team checks every bolt and every cable.

V. Reporting the results - the results of the audit are recorded and reported to managers.

2. Assessing the condition - now that we have examined the greenhouse, we need to decide what to do with it next.

A. We analyze the cost of greenhouse automation and note which parts are easier to replace with new ones or introduce completely different modular systems

b. We analyze which parts we will modernize and how much production characteristics will ultimately improve.

3. Automation plan. Now that we have assessed our greenhouse and decided what we will implement, we can plan the modernization itself.

A. Parts list - we plan which parts we will have to purchase, compare their cost, efficiency and reliability.

b. Time required for automation – Knowing what parts we will purchase and the scope of work, we can estimate the length of time required for modernization.

V. Labor cost – we evaluate the cost of our specialist's wages and whether it is necessary to hire invited specialists or whether our own workers are enough for the work.

4. Search for suppliers - most of the parts that we need to purchase are located abroad, and it will be easier and cheaper to buy them all at once from a supplier than to search and buy individually, and then arrange delivery.

A. Conditions - first we limit our list of options by introducing two conditions we need: first, the supplier must have all the information we need; Secondly, they must make the delivery themselves.

b. Price/quality analysis – our conditions are not very strict, so we can confidently assume that we still have a sufficient list of possible suppliers. We or analysts will evaluate them according to the selected criteria and reduce the list.

V. Choosing the best offer - no, we have a list of analyzed suppliers, we just have to choose the best options.

5. Modernization - we can finally begin to achieve the goal of our task - automation.

A. Disassembly - we disassemble our greenhouse except for the walls and remove all modules that we plan to change or repair.

b. Repairs – Now that we have unrestricted access to all parts of the greenhouse, repairs and maintenance have become much easier.

V. Assembly – we install new, improved modules and reassemble the greenhouse.

d. Final tests - the upgrade is complete, but to make sure everything is in order, we carefully test the operation of all systems and find out its improved characteristics.

Activities and AON diagram. Now that we are sure what we should do it’s time to determine activities which we should do, critical path of such activities, estimated time of project completion [50].

Table 3.1 – Activities and their description

Act.	Name	Dur., days	Description	Predecessors
A	Greenhouse inspection	1	We inspect our greenhouse to determine its exact replacement module.	-
B	Evaluation of condition	0.5	We evaluate inspection results, deciding what should we repair and what should we change entirely.	A
C	Creation of modernization plan	1	Based on our evaluation we create a modernization plan, deciding exactly which details will we need, their cost and quality, etc.	B
D	Contacting suppliers	1	Then we should contact our suppliers and order a shipment of required details from them.	C
E	Transportation of temporary structures to the greenhouse	0.5	While our parts are on their way to us, we can transport temporary structures (such as a crane) from Kyiv to the location chosen for modernization in the Kyiv region.	D
F	Suppliers' delivery of details	3	We pay for the details and the delivery	D
G	Modernization of greenhouse	7	Now that we have all required components, we can start the modernization itself. Of old greenhouse only carcass and will remain while entrails we be changed almost completely.	F, E
H	Testing the greenhouse	2	After modernization our greenhouse will be fully tested to ensure that it is safe to drive and note improved performance.	G
I	Putting the greenhouse into operating mode	0,5	We are launching the first batch of lettuce on the grove	H

Source: developed by author

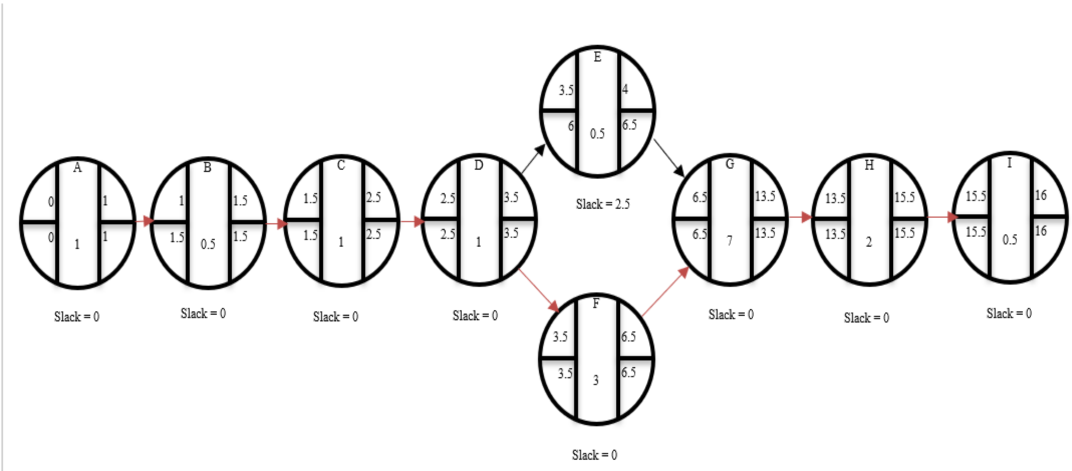


Figure 3.6 – AON diagram, Critical path of the activities

Source: developed by author

Table 3.2 – Calculation the critical path and slack for an AON diagram

Name	**Act.**	**Pred.**	**Dur. (days)**	**ES**	**EF**	**LS**	**LF**	**Slack**	**CP**
Greenhouse inspection	A	-	1	0	1	0	1	0	Yes
Evaluation of condition	B	A	0.5	1	1.5	1	1.5	0	Yes
Creation of modernization plan	C	B	1	1.5	2.5	1.5	2.5	0	Yes
Contacting suppliers	D	C	1	2,5	3.5	2,5	3.5	0	Yes
Transportation of temporary structures to the greenhouse	E	D	0.5	3.5	4	6	6.5	2.5	No
Suppliers' delivery of details	F	D	3	3,5	6,5	3,5	6,5	0	Yes
Modernization of greenhouse	G	F, E	7	6,5	13.5	6,5	13.5	0	Yes
Testing the greenhouse e	H	G	2	13.5	15.5	13.5	15.5	0	Yes
Putting the greenhouse into operating mode	I	H	0,5	15.5	16	15.5	16	0	Yes

Source: developed by author

Budget. Setting up the budget for any event has high importance from the point of further management of the occasion. In our case, we used a special step-by-step guide: research to understand the industry, evaluate past events, determine the event and the overall budget, create a high-level plan, estimate the precise costs.

1.1 For activity A, we need to allocate a salary budget to three members of the commission: 3 employees (one electrician, one agronomist and one installation engineer). Average salary per working day -1000 UAH.

3 * 1000 = 3000 UAH

1.2 For activity B – We evaluate condition of the greenhouse, deciding what module we are going to change. For this we need the developer engineer whose salary per day of work approximately - 1500 UAH. He will waste about half of a day at this task therefore his fee will be – 750 UAH.

1.3 For activity C – We need to plan our modernization, what details are we going to use, what performance of the greenhouse we are aiming for, etc. This part of work is done by engineer planner with approximate salary of 1500 UAH

1.4 For activity D we are holding a tender with the 500 UAH fee for the organization, then our analyst is going to pick the best one for us for a fee of 3750 UAH per day.

3750 + 500 = 4250 UAH

1.5 For activity E – Transportation of temporary structures to the greenhouse, we need to pay drivers' salary and buy the fuel. Driver salary for a day will cost about a 1000 UAH. We will need 100 liters of diesel to arrive at our destination, price of diesel is 46 UAH per liter. It will day half of a day for a truck to arrive therefore driver will receive 500 UAH

Therefore: 100*46 = 4600UAH

4600+500 = 5100 UAH

1.6 For activity F – after we picked our best choice, we need to pay for both the details and the delivery. On average a complete set of details for greenhouse modernization with 50% efficiency will cost approximately 2.5 million UAH

1.7 For activity G – the modernization itself we already have the details and the greenhouse, the only thing left is to pay the workers themselves. On this project full team of 8 engineers will work for 7 days therefore

Engineers' salary = 1000 * 8 * 7 = 56000 UAH

1.8 For activity H the full testing of greenhouse we will need two people for two days. Salary for driver and test engineer: 3200/day therefore:

3200*2 = 6400UAH

1.9 For activity I we putting the greenhouse into operating mode.

Project Crashing. It is scientifically defined that the process by which we shorten the duration of a project in the cheapest manner possible is called project crashing. Associated with this crash time is the crash cost of the activity. Crashing a project basically includes 4 steps that will be used below.

Suppose that we have 20 days to finish our project of greenhouse modernization. The critical path of our project is 16 days meaning that we won't have any problems with the timetable. But suddenly something happens, for example a surprise inspection. Our superiors want to look good and progressive, and show off their new greenhouse, therefore our time limit is crushed from 20 days to 12 days, though we also receive increased budget. First, we need to calculate crash costs which are shown in the Table 3.3.

Table 3.3 – Normal and Crash cost of Greenhouse Modernization

Activity	Time (Days)		Cost (UAH)		Crash cost per day	Critical Path
	Normal	Crash	Normal	Crash		
A	1	0.5	3000	4000	2000	Yes
B	0.5	0.25	750	1000	1000	Yes
C	1	0.5	1500	2000	1000	Yes
D	1	0.5	4250	4750	1000	Yes
E	0.5	0.5	7112	7112	0	No
F	3	2	2500000	2567000	67000	Yes
G	7	3	56000	72000	4000	Yes
H	2	1	6200	9000	2800	Yes
I	0,5	0.5	7112	7112	0	Yes
Total	16	8.75	2585924	2673974	78800	-

Source: developed by author

First thing that we have to note is that we cannot crash activities E and I as whatever we will do, we can't increase the speed of a train.

For activity F delivery of the details to the place of greenhouse modernization. To decrease the duration of the activity we have to take delivery into our hands. The details cost will remain 2.5 million UAH and we will have to send out trusted manager abroad, therefore we have to pay for his airplane tickets for 50000 UAH, then we have to pay for his stay there – 15000 UAH, finally we have to organize the delivery itself.

We will need a train carriage to unload our details into, more than that we need that carriage immediately – approximate price for lease of such carriage is 2000 UAH. Therefore, we will need to pay additional 67000 UAH.

Our most time-consuming activity is G – Modernization which we can crash. We can this by using two ways: First – increase number of workers working on a project; Second pay them more for overwork and increased efficiency. By combining both methods, I believe that we can decrease duration of activity F from 7 days to 3 days. But the costs will increase scientifically as well.

We will have to hire second team of workers and increase a from 1000 UAH to 1500 UAH therefore: 1500*16*3 = 72000 UAH.

Next most time-consuming activity is testing and again we can use both methods to decrease testing duration to one day.

We will have to increase salaries from 3200 to 4500 UAH, and considering that number of workers doubled, cost of testing will be 9000 UAH. Activities A, B, C and D can also be crushed by adding additional workers and increased salary. In all cases it will reduce duration approximately by half. To conclude our calculations:

- We can crash activity A to 0.5 days while paying additional 1000 UAH
- We can crash activity B to 0.25 days while paying additional 250 UAH
- We can crash activity C and D both to 0.5 days while paying additional 500 UAH for each.
- We can crash activity G to 3 days while paying additional 16000 UAH
- We can crash activity H to 1 day while paying additional 2800 UAH.
- We can crash activity F to 2 days while paying additional 67000 UAH.
- We cannot crash activities E and I.

As we can see from the table if we crush our project to our maximum capability, we will decrease project duration to 8.75 days while paying additional 88050 UAH. As the Crushing of the activity F, both introduces unnecessary risk, paperwork and large cost it is propose to use it only if all other options are already used and haven't achieve desired result.

PERT and probabilities of project completion. To start this part, we need first prepare a table with time estimates.

Table 3.4 – Time estimates: optimistic, most likely, pessimistic, expected

Activity	Optimistic (a)	Most likely (m)	Pessimistic (b)	Expected (t)	Variance
A	0.5	1	1.5	1	0.0278
B	0.25	0.5	1	0.54	0.0156
C	0.5	1	1.5	1	0.0278
D	0.5	1	1.5	1	0.0278
*E	0.5	0.5	1	0.58	0.0069
F	2	3	5	3.17	0.25
G	3	7	10	6.83	1.3611
H	1	2	3	2	0.1111
I	0.5	0.5	1	0.58	0.0069

Source: developed by author

1. Expected time Variance

1.1 Expected time

To find Expected time t, the beta distribution weights the three time estimates as follows:

T = (a+4m+b)/6

T(A) = (0.5 + 1*4 + 1.5)/6 = 1

1.2 Variance

To calculate the variance of an activity we use the formula:

Variance = [(b-a)/6]^2

Variance(A) = [(1.5-1)/6)]^2 = 0.0278

2. Calculating the project variance and standard deviation

2.1 Project Variance

Project Variance is a sum of variances of all activities that lie on the critical path. In our case only activity E doesn't lie on the critical path. Therefore:

Project Variance = 0.0278+0.0156+0.0278+0.0278+0.25+1.3611+0.1111+0.0069 = 1.8281

2.2 Project Standard Deviation

Project Standard Deviation = $\sqrt{Project\ Variance}$

Project Standard deviation = $\sqrt{1.8281}$ = 1.3521

Conclusion: The most expected time of the project completion is 16.697 ≈ 17 days and this time can deviate on average by 1.3521 days.

3. Calculating three project completion estimates of the probabilities for different due dates.

3.1 The probability of project finishing on or before 20 days deadline

Z = (due date – expected date of completion)/Project standard deviation

Z = (20 – 16.697)/1.3521 = 2.44

$P(z<2.44) = 99.27\%$

Conclusion: There is 99.27% probability of project completion within 20 days.

3.2 The probability of project finishing on or before 16 days deadline

Z = (16 – 16.697)/1.3521 = -0.51

$P(z<-0.51) = 30.85\%$

Conclusion: The probability of project finishing within 16 days is 30.85%

3.3 The probability of project finishing on or before 14 days deadline

Z = (14 – 16.697)/1.3521 = -1.99

$P(z<-1.99) = 2.33\%$

Conclusion: The probability of project finishing within 14 days is 2.33%

Evolution of Hydroponics Technology: A Journey Towards Sustainable Agriculture:

This exploration unfolds the captivating narrative of hydroponics technology, charting its evolution from rudimentary systems to the sophisticated, sustainable agricultural method we recognize today. The topic delves into the historical context, pivotal advancements, and the transformative impact that hydroponics technology has had on modern agriculture.

Historical Roots of Hydroponics:

Hydroponics finds its roots in ancient civilizations, where rudimentary forms of soilless cultivation were employed. This section provides an insightful look into the historical origins, shedding light on early experimentation and the rudimentary hydroponic techniques used by ancient cultures for crop cultivation [50].

Emergence of Modern Hydroponics:

The modern era witnessed a resurgence of interest in hydroponics, marked by scientific inquiries and experimentation.

This segment explores the key milestones, such as the pioneering work of scientists like Julius von Sachs and William Frederick Gericke, who laid the foundation for modern hydroponics technology during the early 20th century.

Advancements in Hydroponics Technology:

The mid to late 20th century witnessed significant advancements in hydroponics technology, fuelled by innovations in nutrient solutions, growing mediums, and system designs.

This section meticulously details the technological breakthroughs that propelled hydroponics into mainstream agriculture, making it a viable alternative to traditional soil-based cultivation.

Technological Components of Modern Hydroponics Systems:

The contemporary hydroponics landscape is characterized by a myriad of sophisticated technological components.

This part of the exploration dissects the integral elements of modern hydroponic systems, including nutrient delivery systems, automated environmental controls, data analytics, and sensor technologies, which collectively contribute to optimal plant growth [51].

Impact on Agricultural Sustainability:

Hydroponics technology has emerged as a beacon of sustainability in agriculture.

This section examines how hydroponics mitigates traditional farming challenges, including water scarcity, soil degradation, and the excessive use of chemical inputs. The focus is on how hydroponics contributes to resource efficiency and environmentally conscious farming practices.

Integration of Automation in Hydroponics:

In recent decades, the fusion of automation with hydroponics has further revolutionized agricultural practices.

This segment explores the integration of automation technologies, including smart sensors, precision irrigation systems, and data-driven decision-making processes, enhancing efficiency and crop yield in hydroponic setups.

Global Adoption and Industry Trends:

Hydroponics has transcended experimental phases to become a globally adopted agricultural practice.

This part of the exploration delves into the global trends and patterns of hydroponics adoption, highlighting regional preferences, industry growth trajectories, and the economic implications of this technology on the agriculture sector.

Challenges and Future Prospects:

While hydroponics has witnessed remarkable progress, challenges persist. This section analyzes the hurdles faced by hydroponics technology, including initial setup costs, technological complexities, and public perceptions. Simultaneously, it explores the promising prospects and ongoing research initiatives poised to further enhance the technology's efficacy.

Conclusion: Navigating a Sustainable Future Through Hydroponics Technology:

In conclusion, the development of hydroponics technology unfolds as a transformative journey, steering agriculture towards a more sustainable and efficient future. This exploration illuminates the path traversed, from ancient practices to cutting-edge technology, positioning hydroponics as a cornerstone of modern agricultural innovation.

Expanding the Conclusion:

The expanded conclusion further delves into the social, economic, and environmental implications of widespread hydroponic adoption. It explores the socio-economic benefits for communities, the potential role of hydroponics in addressing global food security challenges, and the positive environmental footprint of this technology. Additionally, it contemplates how collaborative efforts and continued research will shape the future trajectory of hydroponics, making it a linchpin in sustainable agricultural practices on a global scale [52].

CONCLUSIONS AND RECOMMENDATIONS

1. The field of automation of logistics activities of agricultural companies faces the challenges of constant improvement and simplification of processes with the participation of people. The future prospects of the field directly depend on the improvement of technologies, and in the near future also the development of artificial intelligence, which is able to independently make decisions and, after fixing a problem, independently solve it. Prospects also directly depend on the development of the world economy, because if we take automation from agricultural companies, then it should first of all be a general development in agrarian countries. The beginning of the historical evolution of the concept of automation is the first manual labor systems of people. And the prerequisites for development were the desire for greater efficiency and simplification of work. The theoretical basis of the concept Automation is multifaceted and extends to several academic disciplines, providing a comprehensive basis for understanding and analyzing the integration of automation in the management of logistics activities at agricultural enterprises. This expanded theoretical framework encompasses a wider range of theories, models and concepts, allowing for a more detailed and holistic study of this dynamic area [53].

2. The advantages of automation include economic efficiency and speed of decision-making and simplification of processes. Challenges for the field of automation are, first of all, improvement and simple upgrading of own technologies. And also a permanent proof of its effectiveness. Achieving the right balance between responsible automation and sustainable farming practices is important not only for a greener future, but also for the long-term viability of agriculture in a changing world. [54].

3. Overview of the Kernel highlights its importance as a key player in the agricultural industry and a major subject of agricultural automation research. The

company's track record, scale of operations, technology investments, sustainability efforts and financial performance combine to paint a portrait of an agricultural enterprise poised for continued success and innovation in the age of automation. Kernel serves as an exemplary case study that illustrates the transformative potential of automation in agriculture. SWOT analysis Kernel not only provides a complete understanding of the company's current situation, but also serves as a strategic compass for shaping its future direction. Kernel's commitment to innovation, sustainability and the smart use of technology underscores its willingness to manage the agricultural landscape with agility and resilience. [55].

4. Evaluating the subsystems of an agricultural enterprise such as Kernel is a multifaceted matter. It reveals the complex network of activities that underlies the company's operations, from logistics to sustainability. Understanding and optimizing these subsystems is imperative to ensuring operational efficiency, quality and sustainability that ultimately positions Kernel as a leader in the agricultural industry. Continuous evaluation and improvement of these subsystems is central to Kernel's commitment to delivering high quality products and responsible agricultural practices. 8. Eeach share carries dividend rights corresponding to existing shares, except for 6,602,000 shares held by the Company's subsidiary Etrecom Investments Limited, which has no voting or dividend rights. As a result of the increase in the authorized capital, the number of issued shares of the Company increased to 300,031,230 shares. These shares together represent 293,429,230 voting rights at the Company's General Meeting, taking into account the 6,602,000 shares held by Etrecom Investments Limited, which do not have voting rights due to their own ownership. Namsen Limited's share increased to 91.61% of the total issued shares or 93.67% of voting/dividend shares. [56].

5. The process of determining the main directions for project interventions in automation in the Kernel is a dynamic and multifaceted work. It includes a thorough assessment of current automation capabilities, identification of areas in need of

automation, technology assessment, cost-benefit analysis, and sustainability commitments. The ultimate goal is to foster innovation, competitiveness and sustainability in the agricultural industry, positioning Kernel as a leader in the ever-evolving world of agricultural automation. The process of justifying proposed automation projects in Kernel is a complex and thorough process. This is a testament to the company's commitment to making informed decisions, ensuring that resources are allocated to projects that are not only promising, but also in line with strategic goals. Justification is the cornerstone of Kernel's journey to innovation, competitiveness and sustainability in the agricultural industry [57].

6. Economic feasibility and ROI calculations are the financial compass that steers Kernel toward the field of agricultural automation. They serve as a litmus test for potential projects, ensuring that resources are allocated to initiatives that not only promise financial returns, but also align with the company's core goals. In a sector where informed financial decisions are key, these calculations are at the heart of Kernel's commitment to innovation, growth and sustainability.

7. The purpose of project is to build a greenhouse with automated water and fertilizer supply. As well as the automation of all possible processes related to the replacement of human activity. We will show our work breakdown structure for this project, PERT analysis, and identify the critical activities of our project. The end result of our project is a fully automated and improved greenhouse with the launch of the first batch of harvest. The impact of hydroponics on the food market is multifaceted, from increasing efficiency and sustainability to transforming consumer expectations. As the world grapples with the need for sustainable and sustainable food systems, hydroponics is a beacon of innovation, changing the agricultural landscape and influencing how we grow, distribute and consume food [58].

8. The application and implementation of technologies in the formulation and delivery of nutrient solutions in hydroponic agriculture can significantly improve the accuracy, efficiency and effectiveness of nutrient management. These technologies

combined into a single system will allow simplified control of the flow of actions during cultivation. The complex provides automatic and manual settings: - turning on/off various devices for a given period of time, including smooth sunrises and sunsets of lighting systems, monitoring and control of temperature and humidity, analysis and adjustment of CO2 with the construction of daily/weekly/monthly charts and much more.

9. Advantages of project:

- control of pumps and irrigation valves by time or water flow, in any combination;
- control of fertilizer consumption during irrigation;
- automatic preparation of a nutrient solution from several components in a given proportion;
- unlimited number of recipes for preparing nutrient solutions;
- management of individual irrigation recipes for each crop/irrigation area;
- automatic correction of pH and EC of water;
- climate control (heating and cooling to maintain the set temperature/humidity);
- control of lighting lamps in the greenhouse (on/off according to a given schedule, including smooth sunrises and sunsets, simulating the natural environment);
- control of CO2 supply in the greenhouse;
- control of solution temperature for hydroponics and aeroponics;
- notification of accidents via notification on mobile phone.

"SMART HYDRA" creates an ideal microclimate, correct and balanced diet and lighting for plants.

10. We created a working modernization plan of 9 activities. Expected duration of the project is 17 days. Expected cost of the project is 2 585 924 UAH. The probability of project completion within 20 days – 99.27%. In the case of deadline shifting, we can crush project down to 8.75 days while paying additional 88 050 UAH. Estimated technical improvement of greenhouse reaches 50% mark. The exact results

will be known in the end of the quarter report of the «Kernel» as the performance of modernized greenhouse will be noted and graded. In our opinion while it could be too expensive to modernize each greenhouse by the proposed method it is still on the table as currently a lot of «Kernel» greenhouses operate far below 100% mark and pushing them to 110 or 120% mark will show significant increase both in their speed and ability to transport goods and passengers. As we draw the curtain on our exploration of the automated controller system in agriculture, the culmination of this project beckons reflection on the transformative journey undertaken. From the inception of the automated controller concept to its integration into the agricultural landscape, this conclusion encapsulates key insights, achievements, and the trajectory ahead [59].

11. The conclusion drawn from meeting project targets extends to the future implications of automated hydroponics greenhouse cultivation. This segment discusses how the successful integration of automation positions the project for scalability, opening avenues for broader adoption within the agricultural sector. [60].

The project's success is not solely measured in technical achievements but also in user satisfaction and stakeholder feedback. This section analyses user experiences, feedback mechanisms, and stakeholder satisfaction surveys to gauge the project's impact on those directly involved in or affected by the automated hydroponics system. [61].

12. In conclusion, the automation of hydroponics greenhouse cultivation stands as a beacon of progress in agricultural technology. The project's successful realization of targets illuminates a path forward for the broader adoption of automated systems in hydroponics. As we navigate the conclusion, it becomes evident that the fusion of technology and agriculture is not just a project milestone but a paradigm shift with far-reaching implications for the future of sustainable and efficient food production [62].

13. This expanded conclusion delves further into the broader implications of the project's success, emphasizing its potential to influence industry standards, regulatory frameworks, and the global discourse on sustainable agriculture. The discussion also

explores the project's alignment with international initiatives for sustainable food production, positioning it as a catalyst for positive change on a global scale. Additionally, the conclusion reflects on the collaborative aspects of the project, acknowledging the contributions of diverse stakeholders and highlighting the importance of continued collaboration for the sustained success of automated hydroponics systems [63].

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