APSTRACT

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USE OF METHODS AND TOOLS (STRATEGY, PLANNING, TRANSPARENCY, ERP, DEVELOPMENT) FOR AN EFFECTIVE SMALL AND MEDIUM-SIZED ENTERPRISE

A case study of SMEs in Szabolcs-Szatm□r-Bereg County in Hungary

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Abstract: *Small and medium-sized enterprises form the engine of the Hungarian economy, both in terms of their number and their employment rate. Therefore, the efficient operation of this sector is in the interest of many economic actors. However, experience shows that today's SME sector still needs to develop in many ways to become efficient. This study aimed to analyze whether SMEs use the necessary methods and tools to be efficient. Planning and the development of strategy are very important methods and tools for efficient and organized work, as it defines and clarifies the direction taken by an enterprise. However, the survey and the in-depth interview showed that they are not necessarily considered important for the participating SME leaders. According to the interview, one of the reasons is that SME leaders have a better understanding of everyday tasks and their implementation than the managers of large companies. Furthermore, in most cases, the SME leader is personally involved in everyday work. This provides the advantage of having the opportunity to fully understand the enterprise, thus managing, and developing it more effectively, as he or she can intervene more flexibly, faster, and more accurately if necessary. However, due to the small size of the organization, the manager also must perform the tasks of several functions (marketing, management, finance, etc.), which require multidisciplinary knowledge and skill. In SMEs, due to their specificities, it is difficult to apply best practices in large enterprises in both management and various functions.*

Keywords: *SMEs, tools and methods, efficiency, Szabolcs-Szatmár-Bereg County*
(JEL code: M21)

INTRODUCTION

Enterprises in the SME sector account for more than 99% of the total corporate sector at both Hungarian and EU levels. According to the latest statistics (2019), there were nearly 827 thousand small and medium-sized enterprises in the country. The number of them has increased significantly in the last 5 years, which has increased by a total of 31% year-on-year. Furthermore, SMEs provided employment opportunities for 65% of those employed in the entrepreneur sector. According to 2019 data, this amounted to the employment of nearly 2.1 million people. More than two-thirds worked in the service sector, 16% in industry, 12% in construction, and 4.8% in agriculture.

In terms of GDP, in 2019 they accounted for 45% of the value-added of enterprises. However, there is a slight decrease compared to the previous year (KSH, 2020). While they form the largest number of companies, their performance remains far behind that of the large companies. What are the reasons that lead to these results?

Making a business plan is an absolute necessity in today's business atmosphere and it is one of the most complex tasks of businesses (Juhász, 2015). Business plans can be of different types. The form, content, and purpose of business planning may differ, depending on whom it is prepared for, at which stage of the business it is prepared, and for what period. Thus, they are for example bank loan presentation plans, investor presentation plans, start-up plans, yearly operating plans, and business sale plans among others (Skripsky, 2002).

The research dedicated to the relationship between rational strategic planning and enterprise performance has been multiplied since the first empirical study conducted by Thune & House (1970) and led to the conclusion of better economic

performance for business planners compared to non-planners. In fact, the question of the relationship between rational strategic planning and company performance has become a topic of interest for researchers in strategic management over the past three decades (Glaister et al., 2008).

Strategic planning is usually a long-term plan that includes directions affecting the entire system of the company. According to Chikán (2005), the task of strategy is to organize a company's stakeholders, in a way that makes forms of movement desirable and enable for stakeholders to serve the company's core purpose effectively (Szőllősi & Szűcs, 2015).

Because it rationally determines a favorable strategic direction, strategic planning can help companies avoid costly mistakes and survive in highly competitive environments (Porter, 1996). Furthermore, other important functions are namely: the functions of projection, decision support, reduction of uncertainty, detailed action plan, and estimation of the future profitability (Laguecir et al, 2010).

In the strategic management literature, rational strategic planning is defined as a logical and continuous process involving a certain number of sequential steps allowing the company to achieve its objectives, namely the definition of the mission and the objectives to be term, the analysis of the environment, the formulation and evaluation of various possible strategies, the implementation and finally the control of the results (Ansoff, 1968). Rational strategic planning is based on the idea that organizations adapt to changes in their environment by making rational decisions (Mbengue - Ouakouak, 2012).

Tactical planning is usually mid-term planning (1-3 years) the determination of the goals of certain subsystems and the necessary means related to the planning of resources (Szőllősi & Szűcs, 2015). There is always a situation in progress with a future largely subject to the influence of uncertain and random events, and the plan drawn up today is always the heir of another plan. (DJITLI, 2015)

Operational planning means the short-term planning of the production and mutual use of outputs with the optimal use of resources. At the operational level, it is necessary to start from the given capacities and supply. Operational planning will take a year or a shorter period of time (Szőllősi & Szűcs, 2015).

In recent years, the contribution of information systems to the competitiveness of companies has been increasingly visible. From tools responsible for dealing with repetitive operations, these have become real tools for managing and optimizing daily activity. Today, integrated management software often even makes it possible to obtain a significant competitive advantage.

Organizations with a rigid vertical structure are breaking up and the integration of the various processes that now must interact constitutes the daily response to companies' need for responsiveness, reliability, and anticipation. It must be able to understand each other, to work effectively between salespeople, technicians, accountants, and logisticians from the same company to optimize overall operations.

This requires having a common language and sharing repositories, practices, and modes of communication. The ERP (Enterprise Resource Planning) represents the ideal tool for such an organization of the company. The risks and costs of integration have always been as great as the benefits of such systems. Therefore, very few small and medium-sized companies are equipped with an ERP today (Pinckaers – Gardiner, 2011).

Not only multidisciplinarity but also interdisciplinarity is required. It is becoming necessary to know how to select and process large quantities of increasingly digital data. It is, therefore, necessary to call on multiple knowledge and contributions to pose and solve a problem, to design and carry out a project. No actor in the system can deal with the problem alone (Le Boterf. ,2018).

The question then arises: are the SMEs using these methods and tools?

MATERIALS AND METHODS

In the following paper, the primary research aimed to answer the question: do most SMEs use methods and tools that make the operation of the business efficient and organized?

To have the most relevant data, the online survey was the most appropriate method. Furthermore, a specialist was involved who views SMEs as outsiders with a professional and experienced perspective. Thus, an auditor was involved in this research by in-depth interview method.

The survey was carried out in 2022 and extended to micro, small and medium-sized enterprises operating in Szabolcs-Szatmár-Bereg County (Hungary). In the first step a database of 70 companies was created, then an online survey was sent to them by e-mail. 38 fills were received from the questionnaires sent, two of which were deleted due to incomplete and inaccurate replies. Thus, the sample consists of 36 complete and processable responses. Therefore, the sample cannot be considered representative, thus the results are not suitable for drawing general conclusions.

The survey consisted of a total of 41 questions. For better analysis of the answers, the filler would choose from the defined answers for most of the questions. However, for almost all questions, the filler was also allowed to answer individually (with the help of the "other" box). The questionnaire included multiple-choice, check box, multiple choice grid, check box grid, and Likert scale closed questions. For every Likert scale question, the range was from 1 to 5. Furthermore, open questions were also applied when the aim was to express the individual opinions of the leaders. As confidential information was included in the survey, anonymity was guaranteed.

The survey contained questions related to short-term and long-term planning, strategy making, transparency of workflows, enterprise resource planning systems, frequency, and types of development.

Nearly half of the companies in the sample are micro-enterprises, nearly 40% are small businesses and 14% are in the category of medium-sized enterprises.

RESULTS

Short-term and long-term planning

Planning is of great importance, as it ensures orderly and traceable work, which is the basis for efficient operations.

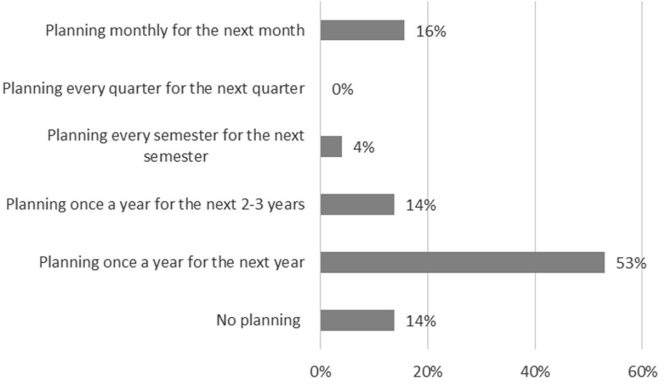
For the analysis of business planning, three elements were asked. How does the SME leader see:

- the importance of short-term?
- the importance of long-term planning?
- the planning's frequency?

For the first two questions, a Likert scale was applied, in which 5 meant that the short/long-term planning is essential, and the 1st meant it is irrelevant. Nearly 67% of respondents consider short-term planning essential. Surprisingly, about 20% of the leaders consider it irrelevant. After that, 8.3% were attributed to medium importance. Both 2nd and 3rd assessments were chosen by one leader.

In terms of long-term planning, there is a greater distribution of the results obtained. Less than half of the leaders consider it essential. The proportion of those who attach medium (3) importance to it is highest. Those who consider it irrelevant (1) have a 3% higher share compared to short-term planning results. If we add up the ratio of those who give valuations (1) and (2) and i.e. for those for whom planning is negligible, this represents more than 30% of respondents, which can be considered a fairly large number. Thus, long-term planning is considered even less important by the leaders interviewed.

Figure 1: Frequency of planning (N=36)



Source: Own editing based on the survey results

In terms of planning frequency, 75% of respondents say they plan once a year for the coming year. 22.2% plan monthly for the next month. Nearly 20% plan once a year for the next 2-5 years, and the same proportion does not plan at all. 5.6% of SMEs plan every six months for the next semester and there has been no response to quarterly planning.

An open question was asked to collect answers regarding the reason that some don't plan at all. Two leaders claim that they do not see the need for planning, because due to their scope of activity, they work according to the daily events and possibilities. According to a leader, the revenue of the company depends on the state's financial payment, thus there is nothing to plan for. This last answer must be from a healthcare company's leader because their revenue is indeed paid by the Hungarian Treasury.

According to the expert interviewed, the planning of SMEs should not be conceived similarly to a large company. For SMEs it can be considered a simpler one, covering only certain elements, and most of the time made only verbally or in the "head" of the leader. The reason is that especially in small businesses, the leader tries to respond to everyday events, and challenges and seize the opportunities that are emerging. On the other hand, due to simple activities and the relatively small number of partners, often with a stable customer base, there is no reason for complex planning. In most cases, the planning focuses on raising wages for the next year and setting new prices, all with the help of simple calculations. It is rare for the interviewed expert to see during her work a company that is engaged in serious planning and belongs to the small or medium-sized enterprise category. After all, in the case of a complex activity, planning is already vital in many cases, but according to her experience, the planning is done according to methods, and systems made by the leader itself, and not based on scientifically supported methods. Interestingly, many micro-enterprises are forced to carry out planning (short- and long-term) due to bank loans. However, they usually do not use it for their activities.

Planning makes sense if the actual results are checked afterward. How typical is the plan-actual review among SMEs?

Nearly two-thirds of respondents say that in all cases the planned and achieved results will be rechecked. However, nearly 20% of them would not check back. Based on the auditor's previously mentioned opinion, it can be concluded that this category includes those who plan for bank loans and not for their activities. Furthermore, the remaining 14% check back, but not always.

Strategy making

According to the auditor, every SME leader has his/her strategy to run and operate their business. These can be very simple strategies, such as: "carrying out activities for the sake of daily living"; "getting as many sales as possible". Larger SMEs, for example, have a strategy for "achieving exclusivity with suppliers and thus providing the most affordable price for customers". Small businesses typically set smaller goals. For them, the main goal is often to provide sufficient means of living for the leader's family, while in the case of larger SMEs they already have a more serious strategy that considers wider economic aspects. In her point of view, these strategies are very rarely written or laid out in a strategy plan, but rather appear in the thoughts of the leader and thus in his actions and decisions. That's why these strategies reach the employees or external stakeholders implicitly. According to the results of the survey, 75% of the respondents do not have a written strategic plan, which follows the previously mentioned opinions of the auditor.

Nearly 78% of those who make a plan only prepare a one-year (operative), and 22% make a two-year plan (tactical). Thus, the respondents mainly make a short-term and mid-term plan.

The auditor added to the previously mentioned results by saying that since these companies are easily seen through by the leader due to their size and simple activities, it allows them to constantly keep in mind the operation, and be informed about every detail, strength, weakness, and problem of their enterprise daily. While in a large company, due to the large size, this is not possible. Therefore, in the opinion of the au-

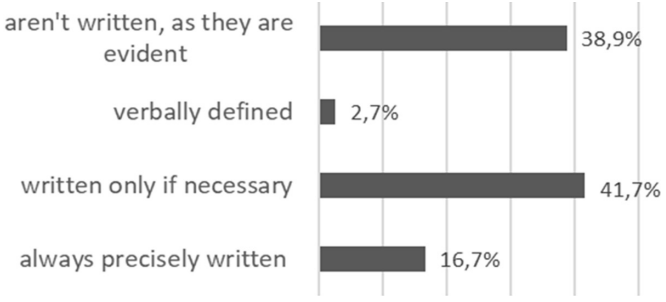
ditor, if the head of a small business has adequate economic knowledge, it is not relevant to him to analyze a serious internal environment, as is necessary for a large company. Analyzing the external environment would be important, however, in her experience, most small business leaders base their decisions, according to the external and internal opportunities they perceive in their day-to-day work, and sometimes from the opinions of acquaintances.

Transparency of workflows

Having a transparent and clear description of the process and workflow of an enterprise is an important tool to increase effectiveness and organized operations. Thus, analyzing its use in the SME sector is necessary.

The existence of accurately described workflows and processes was true in the case of nearly 17% of respondents. Furthermore, 42% will be given an accurate description if necessary. While 39% of the leaders surveyed declare defining it verbally. Finally, 3% say that the processes are self-evident and therefore not present in any explicit form.

Figure 2: Workflows are: (N=36)



Source: Own editing based on the survey results

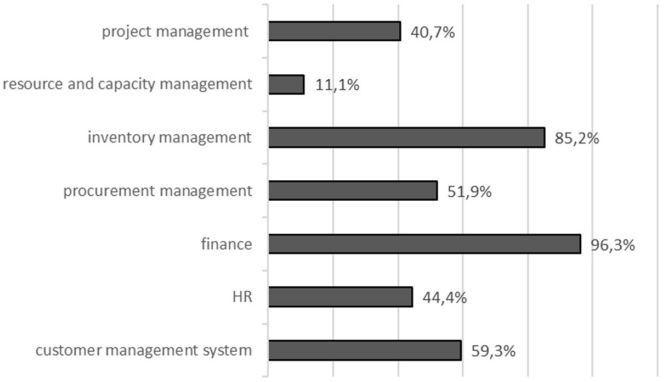
According to the results of the survey, the respondents don't necessarily feel the importance of this tool. Despite it makes the tasks of the employees clear, more accurate, and understandable, thus providing safety for both the employee and the leader. It is also of paramount importance because it will enable everyone to operate within their competence. However, it is true that if the leader can clearly define this verbally, it can also be effective in a very simple activity. During the interview, the auditor pointed out that the activities of SMEs are in most cases simple, which is why in most cases the work processes are defined verbally. Nonetheless, she believes that the processes described in SMEs are often because they are mandatory for some jobs or activities.

Enterprise resource planning systems

IT preparedness and modernity are largely reflected in the use of enterprise resource planning systems. Are SMEs benefiting from this opportunity?

According to the survey, 75% of the respondent's businesses use it, while 25% do not. Micro-enterprises with 1-3 employees do not use such systems but use programs used by individuals (for example, Excel).

Figure 3: Types of ERP used (N=27)



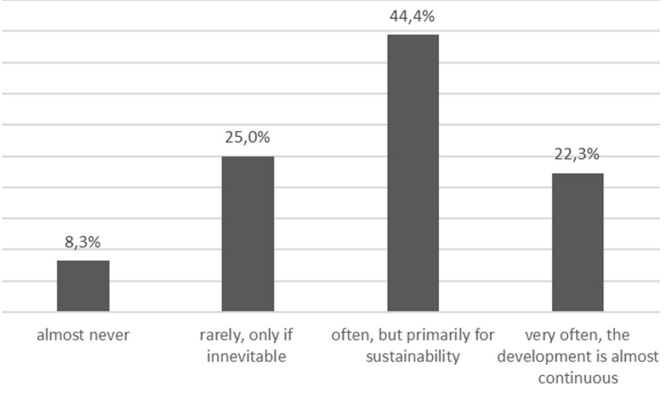
Source: Own editing based on the survey results

Regarding the type of enterprise resource planning systems used, nearly 96% contain financial functions, followed by inventory management functions (85%). Since inventory management is not relevant for all the businesses surveyed, the proportion received can be considered positive. However, a customer management function is necessary for all areas of activity, so the 60% ratio can be considered small. Moreover, 44.4% use HR functions, 52% procurement, and 41% project management functions.

Frequency of developing

In our modern world, a business remains sustainable only if it is constantly developing and able to adapt to changes. Continuous development is the basis of life, however, in our time, changes are extremely fast, which on the one hand means many incredible opportunities for enterprises, and on the other hand, it also means difficulties, since change is always an additional investment of energy.

Figure 4: Frequency of development (N=36)



Source: Own editing based on the survey results

The survey's results show that among the 34 SMEs for the largest proportion, the development is often, but primarily for the sake of survival (44%). This suggests that almost half of the respondents can ensure the sustainability of the business through the development, but further growth is not the goal of the development. While 25% declare that they rarely develop

and only if it is unavoidable. Regarding the previously mentioned tools, there is no growth target here either. According to the auditor for many SMEs, large-scale growth is not a primary objective, as long as the benefits provide a comfortable life for the leader's family. However, the emergence of market opportunities is another matter as taking advantage of those opportunities will naturally lead to growth and development.

Moreover, 8% of the respondents rarely develop. Thus, the question is, how far will these businesses be able to operate in the long run? Finally, nearly 20% of respondents develop very often, almost continuously, suggesting that they are highly dynamic and flexible businesses.

Types of development

For most of the participants, developments concern IT systems, which makes sense since it is the area where the fastest change is taking place. This is followed by technological developments (nearly 80%) since for many activities the most important element of efficiency is the existence of modern technology. A little more than half of the respondents also develop workflows, which can be considered a positive element, since it is also the basis for improving efficiency. The introduction of a new product or service can also be seen in a fair number (45.5%). However, the 42% share of renovation and creation of a modern job environment is considered insufficient because renovation is often a natural consequence of the use of a fixed asset. Furthermore, by creating the most pleasant environment for its employees, a company promotes good cooperation and more efficient work. Marketing development, partner relationship development, and product or service development are less common. The research development is carried out exclusively by one filling company.

Overall, there are some positive results from the developments. However, it turned out that most of the developments are aimed at complying with technological and IT developments, thereby ensuring the survival of the enterprise.

The question is, how much have the improvements helped to make it work more efficiently? On a Likert scale of five, two-thirds of respondents declare that the different types of development introduced have promoted efficiency (5 ratings). 4 and 3 evaluations were chosen by nearly 30% of leaders, which leads back to how they did not necessarily achieve more efficient operations. A development may come at a high cost and can only be interpreted in the long term, its effectiveness. It is also true that development may be inevitable, but due to its nature, it does not necessarily increase the efficiency of the company.

CONCLUSION

The results of the survey show that planning is not necessarily considered an important tool, especially for long-term planning. The most characteristic is planning once a year for the next year. It can be concluded that planning and strategy, which are key methods and tools for achieving efficiency and organization, are not present in a written or explicit way in most SMEs participating in the survey, especially in micro and small enterprises. Due to their size, leaders can easily understand the operation of their business and, in daily communication, can communicate their strategy explicitly or implicitly. Micro and small enterprises operate in a similar way to a family, where planning and strategy are based more on verbal agreements, which in many cases are determined based on existing opportunities and situations. Furthermore, it turns out that due to the highly changing external environment and their short-term vision, SME managers do not see the point in preparing a strategy or planning beyond one year. However, if it is prepared, it is done to meet the expectations of financial institutions. Regarding enterprise resource planning systems, the results show that they are slowly making up for their backlog. They are also successful in several areas of development, but the main reason for the development is to ensure the sustainability of the enterprise. However, they strive to utilize changes in the world in its operations, especially in the field of information technology and technology. Based on the results, the question asked at the beginning of the primary research could therefore be partially answered positively, as there is a noticeable effort to use the right tools, but it is not typical for the use of methods.

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FOOD WASTE IN EU COUNTRIES

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Abstract: *The biggest challenges of our time include meeting the demand growth resulting from the explosion in population growth and achieving sustainable management. In terms of food, the most significant problem is, on the one hand, that a large part of the population is hungry and, on the other hand, excessive food waste, which results not only in wasted food but also in wasted resources used for its production, transport, packaging and storage. Do to this the unconsumed food has a profoundly negative impact on the environment and the economy. There is a pressing need to prevent and reduce food waste to transition to a resource-efficient Europe. In this study, we would like to show how food waste changes in different countries, focusing on Europe. Our results show a significant discrepancy between Member States' data and where waste is generated. We find no significant correlation between GDP per capita and total food waste, but we find a moderately strong correlation between GDP per capita and restaurant waste at the point of generation.*

Keywords: *food loss, food waste EU-27*
(JEL code: M21)

INTRODUCTION

Food wastage is essential to global food security and good environmental governance, which are closely related to environmental (e.g. energy, climate change, water, availability of resources), economic (e.g. resource efficiency, price volatility, increasing costs, consumption, waste management, commodity markets) and social (e.g. health, equality) impacts (Stenmarck et al., 2016). Of these factors, the efficiency of economic factors is perhaps the easiest to measure, as there are different levels of indicators available (Nábrádi et al., 2008, Kovács-Szűcs 2020). Efficiency measurement has been used in many sectors to assess performance and the impact of government decisions (Kovács, 2014).

Different studies show that between 1/3 and 1/2 of the world's food production is not consumed (Gustavsson et al., 2011; Bio Intelligence study, 2010), leading to negative impacts throughout the food supply chain, including households. Consumer awareness is also a significant factor in relation to food waste, Bauerné et al. showed in their study that conscious food consumer behavior is present to varying degrees among young people and environmental awareness comes to the fore among conscious food consumers, and in many cases they avoid food waste, as compared to those who do not consider themselves to be health- and environment-conscious (Bauerné Gáthy et al., 2022).

There are several definitions of food waste. The definition of FUSIONS is in line with the official definition adopted by the European Commission (EU, 2018), except that the latter does not include crops ploughed back into the soil or not harvested.

Food loss is the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retailers, food service providers and consumers (FAO, 2021). Food waste refers to all discarded, burned or otherwise disposed of along the food supply chain from harvesting/cutting/catching to the retail level, but is not consumed or used for any other production purpose, such as animal feed or seed (FAO, 2022).

The forms of food waste:

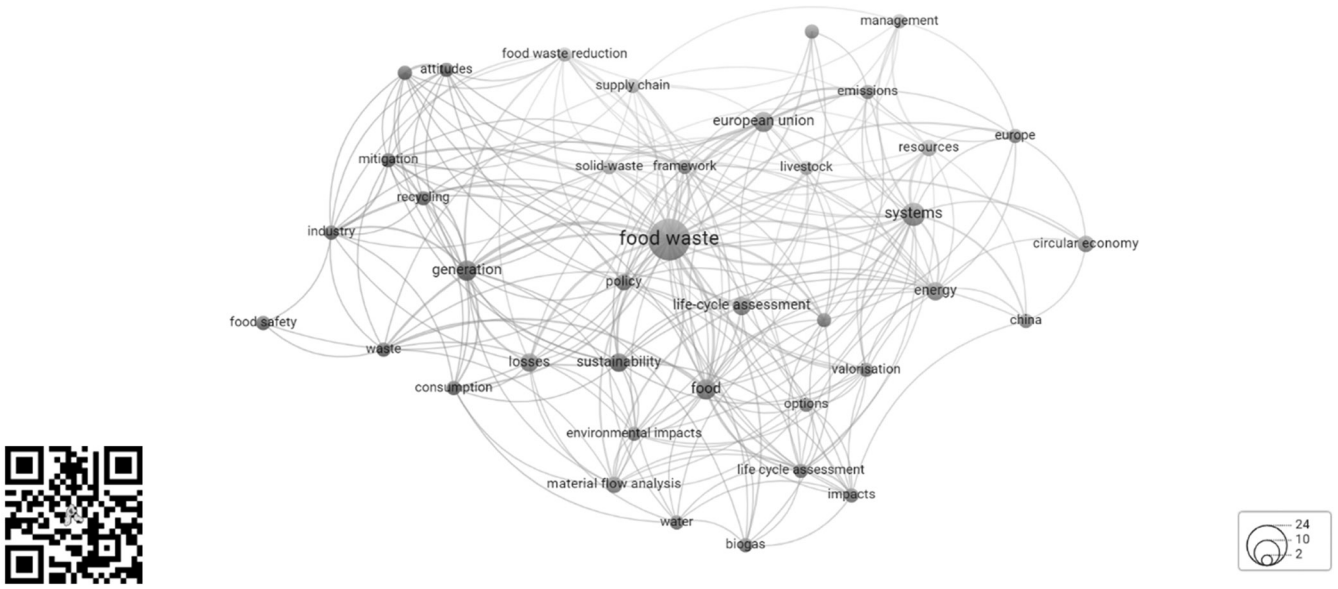
- Fresh food that is not considered optimal (e.g. size, shape or colour) and is discarded during sorting;
- Food that is discarded by retailers or consumers when the expiry date is near or past;
- Discarded, unused or leftover food from households or restaurants (FAO, 2022).

Bibliometric studies provide an intriguing overview of a country's scientific activity and its position in the international aspect, providing essential information to aid those in charge of scientific policy in taking the most appropriate actions (Ser-

toli et al., 2022). A bibliometric analysis was conducted using VOSviewer software on the Web of Science database to map the academic literature on food waste. Thus, we identified essential links by analysing 421 publications' titles, abstracts, and keywords. Only keywords that reached a minimum of 3 occurrences were analysed. Thirty-nine keywords achieved this, which were classified into 5 clusters (Figure 1.). This number has been significantly reduced to explore the most important links between the literature, and a narrowing has been carried out by searching keywords of food waste in the EU.

In Figure 1. we can see the essential links to food waste. On the one hand, connections can be demonstrated with industry, food safety, mitigation, recycling, attitudes, sustainability, etc. Another side is emission, energy, circulation economy, reduces. This study focuses on the connection between food waste reduction, supply chain, and European Union topics.

Figure 1: Food waste in VOSviewer



Source: VOSviewer software on the Web of Science database, 2022

Latest estimates suggest that approximately 931 million tonnes of food waste were generated in 2019 in the world, of which 61% came from households, 26% from food service, and 13% from retail (UNEP, 2021). Around 88 million tonnes of food waste are generated annually in the EU (Denmark et al. (2016). Our research shows that food waste in the EU is primarily generated at the processing stage rather than by households.

Food waste levels are similar in Europe's high, upper-middle and lower-middle-income countries (UNEP, 2021). In complement to the Food Loss Index, developed by the Food and Agriculture Organization of the United Nations (FAO), the Food Waste Index covers the later stages of food's journey – food waste – occurring at household, food service and retail levels.

Figure 2. summarises specific examples of different types of food waste, grouped by food supply chain stages and major food groups. Figure 2. clearly shows at which stage of the food chain food losses of plant and animal origin occur. In primary production, crop losses are mainly due to unharvested crops, crops left in the field, unsold crops, and rotten or damaged vegetables and fruit. In the case of products of animal origin, this mainly includes food that has not been correctly stored and discarded fish. The second stage is the processing in the food supply chain generated during processing, and it includes animal and vegetable parts which are unfit for human consumption (skin, bones, etc.) and products damaged during packaging. The third stage is distribution, where the main problems are unsold or expired products and damaged/rejected foods during storage and quality control. The last but not least stage is consumption, where the loss is due to improper storage and non-consumption of food.

Figure 2: Potential food waste by stage in the food supply chain

Stage in food supply chain	Crops	Animals and animal products
Primary production	Edible products not harvested Edible products left in the field Edible products harvested but not sold Rotten fruit or vegetables Products damaged by machines Spillage of products Produce damaged due to mishandling Products stored in poor conditions	Dropped/discarded fish Food lost due to poor storage
Processing	Processing problems (e.g. inefficiency, contamination, etc.) Inedible food waste (e.g. skin, seeds, bones, fruit stones, etc.) Food damaged due to improper packaging	
Distributing	Food damaged due to lack of cooling/storage facilities Expired food Unsold food Food rejected after quality controls	
Consumption	Food damaged due to lack of cooling/storage facilities Food not consumed e.g. due to surplus, expired, inadequate packaging, low consumer appeal and plate waste (i.e. food served but not eaten). Inedible food waste (fruit pulp, bones, etc.)	

Source: adapted from Corrado et al., 2017

As Figure 3. shows, the food waste is divided into edible food products and inedible parts. These constitute the total food waste in the relevant part of the food supply chain.

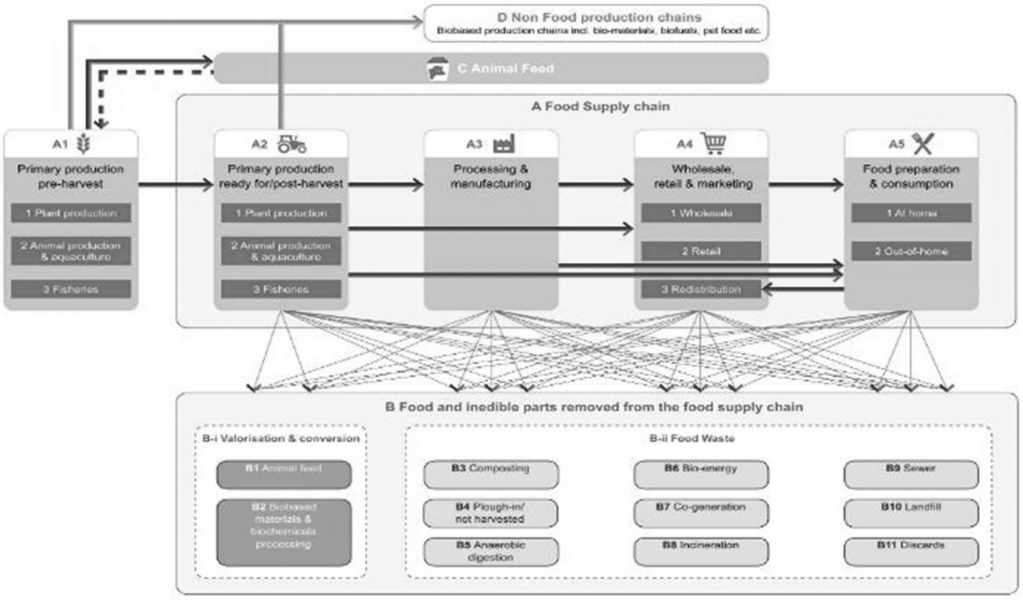
The FUSIONS framework defines food waste as "any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed (including composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea" (FUSIONS, 2014).

The inedible parts of food are those parts that are not intended for human consumption, such as bones, crust and pits/stones. There is no universally accepted definition of the inedible fraction of food waste, which is influenced by several variables, including cultural habits (e.g. pigs' ears or chicken feet are consumed preferentially in some countries), socio-economic factors, food availability and prices, technological development, international trade and geography (EC, 2020).

Therefore, food waste includes parts of food intended for consumption and parts, not for consumption (EC, 2019). However, food waste does not include the following:

- Pre-harvest losses, i.e. losses that occur before the raw material is ready for harvesting or slaughtering, such as weather-related crop damage, which is thus recorded as agricultural waste;
- by-products, i.e. edible or non-edible materials from food production and processing, such as shells, bones and scrapings, which are then used for other purposes (e.g. cosmetics, glues, animal feed);
- food packaging such as cans, protective packaging or plastic containers (although edible packaging is considered food because it is intended for human consumption) (EC, 2020).

Figure 3: Defining the Food supply chain and Food waste



Source: Stenmarck et al., 2016

MATERIALS AND METHODS

This study analysed food waste generated in EU member countries based on the EU's Food Waste Index Report published in 2021.

Two hypotheses were formulated:

H1: The old EU-15 Member States have a higher environmental awareness than the 2004 enlargement countries, suggesting that food waste per capita is lower in the EU-15 than in the 2004 and subsequent accession countries.

H2: In some Member States, food waste generation is mainly due to food wastage at home.

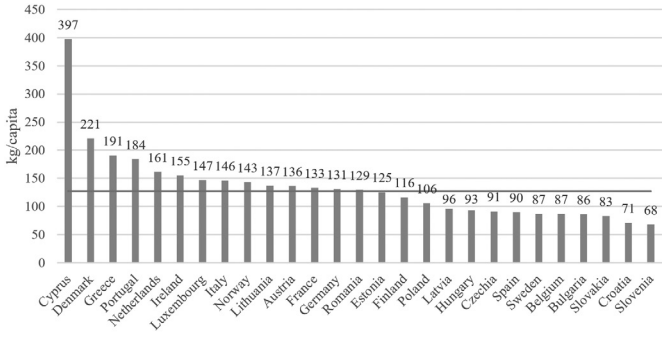
In the analysis, the authors used multivariate statistical analysis methods. Pearson correlation coefficients describe the relationship between the variables and evaluate the development of the relationships between the individual indicators. Relationships and order were analysed using hierarchical clustering based on ward linkage and Euclidian distance. Data analysis was processed using SPSS 25. Where statistical significance is evaluated using p-value without further explanation, we assume a significance level at $\alpha = 0.05$.

RESULTS AND DISCUSSION

There are significant differences in the amount of food waste across the EU, as Figure 4. shows. The most wasteful country is Cyprus, where the amount of waste generated is three times the EU average and almost double that of Denmark, the second-worst performer. Based on the data, a cluster analysis was performed, and the Member States were classified into 3 clusters. Cyprus was placed in the first cluster, as it is the only Member State with an outlier of nearly 400 kg/

year. The second cluster includes 14 countries with food losses exceeding 90 kg/person/year (Denmark, Greece. Portugal, Netherlands, Ireland, Luxembourg, Italy, Norway[1], Lithuania, Austria, France, Germany, Romania, and Estonia). The third cluster is made up of 12 countries where the value is below 90 kg/capita/year (Finland, Poland, Latvia, Hungary, Czech Republic, Spain, Sweden, Belgium, Bulgaria, Slovakia, Croatia, and Slovenia).

Figure 4: Amount of food waste in EU member states, 2020



Source: own editing based on EUROSTAT, 2022 data

As Figure 4. and the cluster analysis shows, the old EU Member States are in cluster 2, and the majority of them produce food waste above the EU average, so our first hypothesis (H1) is that the old Member States have higher environmental awareness and therefore lower specific amounts of food waste than the countries that joined in 2004 and afterwards are rejected.

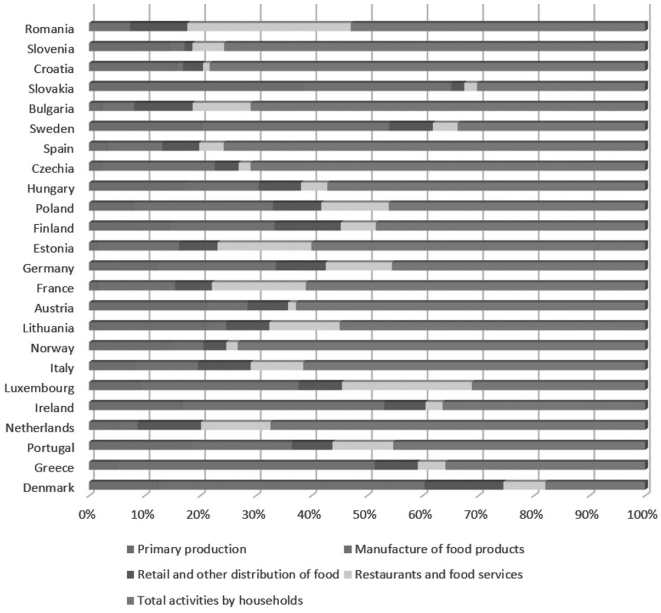
We then looked at the proportions of food waste by place of origin in the Member States. The results are shown in Figure 5. The food waste shows significant differences between countries - in Denmark and Finland 60% of food waste is generated in households, while in Lithuania, the figure is less than 20%. If we express food waste in all countries as 100%, we can see the distribution between places.

Given the outlier value of Cyprus, we assumed that the outlier was since Cyprus is one of the most popular holiday destinations in the EU, with five tourists per inhabitant per year, and therefore the vast majority of food waste generated comes from restaurants and catering waste. However, our proposal had to be rejected for two reasons. Firstly, the database is from 2020, the first year of COVID, when tourism in Cyprus dropped by almost 90%, so many catering outlets were closed or operating at a lower capacity. On the other hand, the compositional data show that this phase generates proportionally the least waste, only 8%. In contrast, half of it is generated during processing.

The results support our second hypothesis that the proportion of the waste generated in each Member State is similar.

Figure 5. shows significant differences between countries in where and how much food waste is generated. If we take the food waste generated in a country as 100%, we can see the proportion of the waste generated in each sector. In primary production, Slovakia has the highest share of total food waste, and Lithuania and Austria have significant shares too. Denmark has the highest share during manufacturing, followed by Sweden and Slovakia. In the retail and distribution stage, Denmark, Finland, Netherlands, Bulgaria and Romania have the most significant shares. The most striking is that almost all countries' most incredible food waste occurs at the consumption stage.

Figure 5: Proportions of food waste by place of origin in the EU countries



Source: own editing based on EUROSTAT, 2022 data

Our results coincide with the United Nations Environment Programme (UNEP) 2021 report, which also identified the household sector as the primary source of food waste.

In Table 1. we calculated the food waste of the retail, food service and household sectors based on UNEP 2021 data. The UNEP 2021 data differ from EUROSTAT's data, which results from different data, calculations and estimates. We added up the amount of waste generated in each sector, so the Total column in Table 1. gives the amount of food waste people can influence through conscious habits.

Table 1 shows that the average total food waste is 113 kg/capita per year. The highest value is found in Greece (175 kg/capita/year) and Malta (167 kg/capita/year), where household waste is the most significant.

Table 1: The retail, food service and household food waste amount in the European countries (kg/capita/year)

Country	Retail estimate	Foodservice estimate	Household estimate	Total
Albania	16	28	83	126
Andorra	13	26	84	123
Austria	9	28	39	76
Belgium	10	20	50	79
Bosnia and Herzegovina	16	28	83	126

[1]*Norway is not an EU member.*

Bulgaria	16	28	68	112
Croatia	13	26	84	123
Czechia	13	26	70	108
Denmark	30	21	81	132
Estonia	5	17	78	99
Finland	13	23	65	102
France	26	24	85	135
Germany	6	21	75	102
Gibraltar	13	26	84	123
Greece	7	26	142	175
Hungary	13	26	94	132
Iceland	13	26	76	115
Ireland	13	56	55	124
Italy	4	26	67	96
Latvia	13	26	76	115
Liechtenstein	13	26	72	110
Lithuania	13	26	76	115
Luxembourg	7	21	89	117
Malta	13	26	129	167
Monaco	13	26	72	110
Montenegro	16	28	83	126
Netherlands	11	26	50	87
North Macedonia	16	28	83	126
Norway	14	5	79	98
Poland	13	26	56	94
Portugal	13	26	84	123
Moldova	16	28	76	119
Romania	13	26	70	108
Russia	14	28	33	75
Serbia	16	6	83	104
Slovakia	13	26	70	108
Slovenia	7	20	34	61
Spain	13	26	77	116
Sweden	10	21	81	112
Switzerland	13	40	72	124
Ukraine	16	28	76	119
United Kingdom	4	17	77	98

Source: own calculation, based on UNEP, 2021 data

They are followed by France, Denmark and Hungary, where the high value is also due to high household waste generation. The data of Albania, Bosnia and Herzegovina, Montenegro and North Macedonia are the same (126 kg/capita/year), probably due to similar calculations and estimation methods. In addition to the countries mentioned above, the following countries are above average Iceland, Latvia, Lithuania, Spain, Luxembourg, the Republic of Moldova, Ukraine, Andorra, Croatia, Gibraltar, Portugal, Ireland, and Switzerland. Bulgaria and Sweden's food waste levels are very close to the average (112 kg/capita/year). The following countries food waste levels have below the average, in descending order: Monaco, Liechtenstein, Slovakia, Romania, Czechia, Serbia, Germany, Finland, Estonia, United Kingdom, Norway, Italy, Poland, Netherlands, Belgium, Austria, Russian Federation, and Slovenia. For each country, it can be established that the most considerable amount of food waste is found in the household sector.

One of the most important indices of the population's food consumption is the quantities of the consumed foods expressed in a natural measure (Balogh, 2008). It would be worth comparing how many percent of the total amount of food consumed is wasted. This fact (the household sector wastes the most food) can be considered favourable from that point of view because the consumption stage is perhaps the easiest way to reduce food waste. With the proper attention and campaigns, consumers could be supported to reduce the amount of food waste in their households.

Table 2: Correlation between each waste generation site and the country's GDP per capita

Correlations			
		GDP/capita	Restaurants and food services
GDP/capita	Pearson Correlation	1	,431*
	Sig. (2-tailed)		,036
	N	27	24
Restaurants and food services	Pearson Correlation	,431*	1
	Sig. (2-tailed)	,036	
	N	24	24
*. Correlation is significant at the 0.05 level (2-tailed).			

Source: own calculation and editing based on EUROSTAT, 2022 data

Finally, a correlation was calculated between each waste generation site and the country's GDP per capita. Our analyses found a moderately strong positive correlation between GDP per capita and the amount of food waste in restaurants (Table 2.). The correlation may be because, in countries with higher economic performance, the population can choose to eat out more often, or restaurant services have taken over the role of home cooking.

By UNEP, 2021 levels of household food waste (the total of edible and inedible parts) are similar for high-income, upper-middle-income and lower-middle-income countries.

For many people on the planet, food is a given, the European consumers benefit from the widest possible choice of quality food products (Bartha et al., 2009). However, for the staggering more than 820 million people who are hungry, food is not a guarantee. Not all countries have sufficient quantities and quality of food, while in other parts of the world obesity is causing socio-economic problems (Vida, 2013). Reducing food loss and waste is critical to creating a Zero Hunger world and reaching the world's Sustainable Development Goals

(SDGs), especially SDG 2 (End Hunger) and SDG 12 (Ensure sustainable consumption and production patterns) (FAO, 2021). So this is the reason why so important to take attention about food waste for each country.

EU's Farm to Fork Strategy has set the reduction of food loss and waste as an important part of the strategy and proposes to set legally binding targets to reduce food waste across the EU by 2023 (EC, 2022).

We, as consumers, can have a direct impact on the food waste problem by paying attention to our own behaviour (Karnai et al., 2021). Make proposals for reduction for each stage/ participant in the food chain, for example a free information booklet to provide recycling opportunities for each product (composting, recipe, school programmes, competitions, camps, other alternative options: community composting, etc.). There is a need for a long-term marketing strategy, an effective information campaign, a well-articulated advertising message, and a way of making consumers aware of this, so that advertising can also have an educational function (Balogh, 2010). Education is important, because in most cases people do not eat and use certain foods, because they do not know how to prepare them properly (Szűcs et al., 2008),which means that food by-products are not used properly, leading to more waste. Less food loss and waste would lead to more efficient land use and better water resource management, positively impacting climate change and livelihoods (FAO, 2021).

Shortening the supply chain would be a key objective for producers, as the shorter the product's journey to the consumer, the less waste is generated. The later food is wasted in the supply chain, the more significant the environmental impact (CO2 emissions, ecological footprint). Each food has a different impact on the environment. The further along the supply chain the food loss occurs, the more carbon-intensive the loss and waste (FAO, 2011). Improving the figures and implementing targeted programmes can only be achieved through continuous data monitoring.

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DRIVING FACTORS BEHIND UGANDA S RURAL PASTORAL COMMUNITIES SOCIAL-ECONOMIC STATUS; A COMPARISON BETWEEN KARAMOJA REGION AND ANKOLE REGION

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Abstract: *In several nations throughout the world, nomadic pastoralists comprise a wide important group but are quite often considered an ethnic minority. They are estimated to constitute over 200 mil-lion people globally, with an economic role that is often neglected despite their unique importan-ce to sustainable development and the ecosystem. They turn deserts and rangelands, where crops cannot grow, into food-producing zones. They are great stewards of the environment des-pite living in challenging circumstances and struggling with the impacts of climate change, conf-licts, and social rejection. This study aimed to analyze the social-economic status of Karamoja, Uganda's largest pastoral region that has consistently stood out as the least developed region in Uganda. The region is naturally endowed with a variety of minerals such as marble, limestone, gold, etc. This has attracted both local and international artisanal and small-scale miners into the region although their contribution to the region's development seems negligible. Three major rural development aspects i.e., social, ecological, and economic dimensions were assessed and compared to the Ankole region, one of Uganda's rural pastoral regions that has over time regis-tered progress in livestock production and regional development. Based on this comparison, si-milarities and differences were identified and used to build the foundation for the development of a SWOT analysis. The region's major strengths are high adaptability levels to climate shocks and communal land ownership. The greatest challenges to the region are cattle rustling, poor infra-structural development, and extremely dry weather conditions. For sustainable development to be realized in the region, there is a need to enhance security to stop cattle rustling and develop-ment of well-focused policy intervention measures strengthening climate change mitigation and coping strategies.*

Keywords: *pastoralism, rural development, sustainable development, SWOT analysis, Comparison*
(JEL code: Q56)

INTRODUCTION

Karamoja is Uganda's dominant pas-toral community positioned in the North-Eastern part of the country. The region has recently attracted national and international attention due to various development chal-lenges that are driven by sociological and ecological factors. Karamoja stands out among Uganda's least developed regions. This is evident due to high levels of income and food poverty i.e., 60.2% and 70% res-pectively (UBOS, 2018a). The region is made up of four livelihood zones i.e., maize-livestock zone, mixed crop zone, apiary po-tato zone, and sorghum-livestock zone. With a population rooted and based in rural areas, most people in the region survive on livestock and crop production. Of late, the developing scope of expanded livelihood activities is growing to include diversificati-on into a wide range of economic activities.

Karamoja region comprises of nine administrative districts (Kotido,Kaabong Moroto, Abim, Napak, Nakapiripirit, Amudat, Karenga and Nabilatuk). The population of Karamoja was estimated at about 1.2m people with the greatest percentage of about 70% residing in rural communities (UIA, 2016). The region generally has a hot clima-te with very minimal rainfall receiving about 920.1 ± 118.9 mm. The temperatures have consistently been raising since 2000, however, the temperature ranges between 16.8 ± 0.5°C and 30.6 ± 0.4°C with a mean range of 32.0 ± 0.7°C and 30.6 ± 0.4°C. The terrain is made up of plains raising towards the eastern parts of the regi-on whose terrain is mostly hilly towards the escarpment and boundary line with the Tur-kana district of Kenya. A big Portion of the region is occupied by Kidepo Valley National Park within the grassland and woodland savannah ecosystems that dominate the region's northern parts. (Egeru et al., 2019).

Despite having a special ministry un-der the office of the Prime Minister of Ugan-da (Ministry of Karamoja affairs), the region continues to grapple with poverty which is accelerated by factors such as unfavorable climate, poor infrastructure, poor farming practices, and insecurity which is due to massive cattle rustling (Egeru et al., 2014). Parts of both Karamoja and Ankole are lo-cated in the rangelands of Uganda's cattle corridor. Rangelands are characterized by highly heterogeneous and widely disinteg-rated resources, whose fluctuation is attac-hed to seasonal changes, time, and inconsis-tent climatic circumstances. The individuals who live in such regions should fight with various factors that manage range productivity, among which precipitation designs assume a significant part. Downpours might fall plentifully in one area for many years, yet flop completely and without advance notice in some given years. The disequilibri-um model of rangeland resource usage and its significance on the movement of li-vestock to adapt to risk is more fit along the cattle corridor in the north-eastern part of Uganda (portions of Karamoja), situated in a dryer, uni-modular precipitation zone, com-pared to the Ankole cattle corridor in south-western Uganda comprised of higher, bi-modular precipitation (Rugadya, 2006).

The nature of the environment in Ka-ramoja has a wider contribution to the Ka-ramajong culture and social life. To get by in this capricious territory, the Karamojong people embraced a nomadic pastoral way of life. They keep livestock and obtain a critical piece of their nourishing needs from the blood drawn from the animals, milk, and meat (Jabs, 2007). It is upon this background that this study sought to answer specific questions i.e., i). What is the connection between Karamoja's environment and the social way of life of the Karamojong people? ii). In what ways do ecological and econo-mical factors contribute to Karamoja's soci-al-economic status? iii). What lessons can the Karamojong people learn from the Anko-le people? The overall objective was to as-sess the extent to which ecologic, and eco-nomic factors contribute to Karamoja's so-cial-economic status in comparison to the Ankole region.

MATERIALS AND METHODS

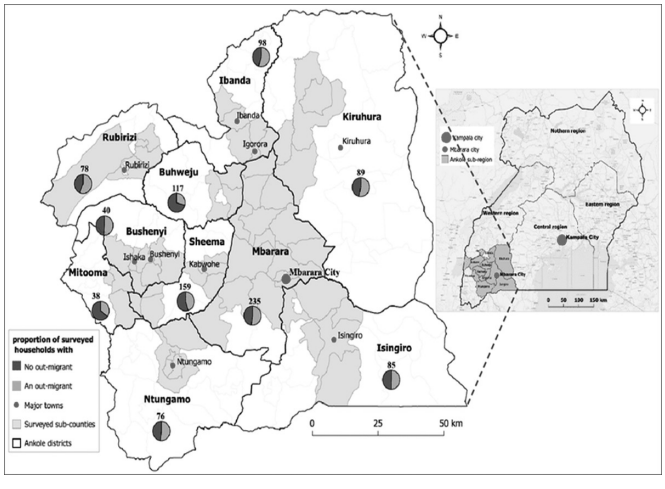
This study was focused on rural pas-toral settlements. The changing patterns and ceasage in unique characteristics of rural areas create a highly problematic phenome-non in the definition of rural areas. Further-more, it is noted that there is no single defi-nition of „rural", making it highly ambiguous (Holland et al., 2003). On the other hand, it is possible to recognize rural areas based on common features such as; areas where hu-man settlements and infrastructure make up only smaller segments of the landscape, with the greater parts being prevailed by fields and pastures or woods and forests, mounta-ins, and water. In addition, the majority of the people spend most of their working time in farming activities, there is plenty and low-priced land, high costs of transaction due to extended distances and less developed infra-structure, and the likelihood of elite capture or urban bias is increased by higher costs of transactions associated with geographical conditions (ASHLEY & MAXWELL, 2002). For the purpose of this study, rangeland sett-lements within the Uganda cattle corridor (Kiggundu et al., 2019; Nakalembe et al., 2017; Nalapa et al., 2017; Roschinsky et al., 2012a; Sempiira et al., 2017) were part of the key features that made Karamoja (Fig. 1) and Ankole (Fig. 2) relevant rural areas with a common characteristic of pas-toralism providing a unique study area.

The research design was based on content analysis. This involves studying documented human communications, including categories such as books, letters, web pages, magazines, poems, paintings, newspapers, songs, and speeches (Babbie, 2020). Content analysis is an approach that enables objective, systematic and quantita-tive explanation of the manifest content of the communication. The method is used to categorize and code (and subsequently analyze) both the manifest and latent content of the data. Manifest content refers to those components that are visible in the data and can be counted. Latent content re-fers to the meaning that may lie behind the manifest content (Saunders et al., 2019). Qualitative comparative analysis (QCA), the name given by Charles Ragin, was utilized to break down the causal attributes of various circumstances by recording the various de-signs of conditions related to each instance of a noticed result. These were then exposed to a minimization methodology that dis-tinguishes the easiest arrangement of condi-tions that can represent the noticed results, as well as their nonappearance (Ragin, 1998). Based on the results, the two regions can be distinguished using identical and non-identical aspects between the Karamoja re-gion and the Ankole region drawn from wi-der dimensions to a specific focus area. To compare the Karamoja region and Ankole region, the analysis of results was broken into Social, ecological, and economical di-mensions. The concept of sustainable deve-lopment and the proposition for its execution is based on the unity of three ma-jor components: social, environmental, and economic. For social and economic interests to be implemented, they should be a subsidi-ary of the ecological function (Kabitova et al., 2016). In this context, rural communities were a major intentional focus for creating a clear overview of the social life and rural development aspects in both regions based on a SWOT grid. The SWOT matrix has been used to monitor and analyze sustainable development practices in various fields to address local, regional, national, and interna-tional issues (Kaymaz et al., 2022). Despite having a wide range of applications, the SWOT analysis has various limitations. It only has the ability to classify the factors into its four groups but is unable to rank and prioritize (Shakoor Shahabi et al., 2018). The independent use of SWOT analysis can not produce a quantified analysis of values and is therefore unreliable in prioritizing alterna-tives during decision-making (Yüksel & Dagˇdeviren, 2007). These limitations can be overcome by the integration of SWOT analysis with Multi-Criteria Decision Making Methods (MCDM) approaches (Chang & Huang, 2006). SWOT analysis has been used in the study of agricultural environments (Suh, 2014). Nomadic pastoralism in Ka-ramoja is not only a social way of life but also a farming activity that can be studied with a SWOT analysis. The terms strength and weaknesses allude to interior aspects that measure the capacities of an entity be-ing surveyed while opportunities and threats allude to external elements that influence the manageability of the entity. Accordingly, the strength and

weaknesses, as inside as-pects for improved social life and rural development, opportunities and threats are viewed as outer aspects beyond the control of Karamajongs (Sergaki et al., 2015). In this study, SWOT analysis was used due to the availability of qualitative evidence from the reviews concerning the four aspects. This study is not highly conclusive but can be a reliable starting point and guiding tool for further studies on Karamoja region through the integration of MCDM.

Figure 1: Location of Karamoja region

Figure 2: Location of Ankole region



Source: (Tumwesigye et al., 2021)

RESULTS AND DISCUSSION

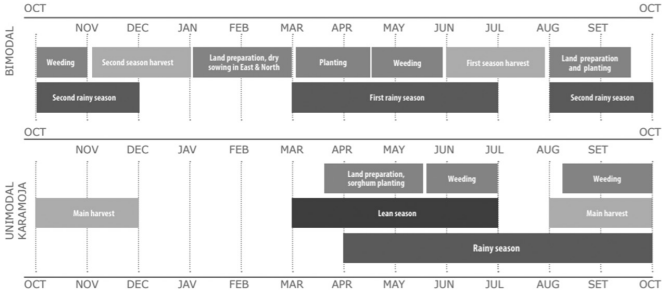
Ecological

From an ecological perspective, Ka-ramoja's climate is unique from all other regions in Uganda which have a bi-modal rainfall pattern with 2 distinct cropping se-asons (Fig. 3). Karamoja has a Uni-modal rainfall pattern with a rainfall season typi-cally commencing in March and ending in October and is accompanied by a lengthy, frequently acute dry season and as a result, a single growing season exists. The annual mean rainfall ranges between 300 mm in the pastoral regions to 1200 mm in the western areas of Abim and Nakapiripirit. Mean annu-al temperatures range from 16°C in the highlands to 24°C in the rest of the region. In a report by (USAID, 2017), it was revealed that the recent droughts in the region had destroyed 50 – 100% of crop yields for affected households. The region's climate di-rectly impacts the availability of water and feed for livestock. Such a climate limits the proper growth of pastures leading to in-adequate feed for livestock. Soils are mainly sandy and of low fertility. These pas-turelands have been used beyond capacity leading to overgrazing. The inadequacy of pasture forces nomadic pastoralists to ma-neuver circumstances by moving during the prolonged dry spell (September to April), resulting in competition for scarce resources and thus continuous conflict. The Karamo-jong keep cattle of a similar type (zebu). The Zebu cattle are well adapted to harsh clima-tic conditions due to their genetic makeup with upward-pointing humps, average body size, and weight, heat resistance, blunt snouts, some tolerance to cold, and well-developed dewlap which is very prominent in bulls (Rugadya, 2006).

The Vegetation dynamics in the Ka-ramoja region can be viewed as the major ecological connection between the Karamo-jong and the Environment. As a tradition, the Karamojong moved their animals in a transhumant way to cope with grazing lands heterogeneity. Notwithstanding, after the aggregation of firearms in 1911 and assua-gement by the colonial government from 1921, movement in and out of Karamoja became restricted. These limitations hin-dered the Karamojong's ability to freely graze their animals in the traditional pas-turelands (Anthony et al., 2020; Shmelev & Filipová, 2017). Following the disarmament operation in 2007, a complete prohibition on animals from Karamoja leaving the sub-area was enforced. This implied that the pastoral families had to get along with their livestock inside the sub-region which was likewise shared with the transhumant Turkana (no-mads from Kenya) who move to Karamoja during the dry season to graze their animals. Vegetation dynamics govern resource usage, administration, and power relations in the sub-region. On several occasions, violence and conflict over water resources and gra-zing lands have been registered due to com-petition for resources (Anthony et al., 2020). On the contrary, The Bahima people of An-kole Sub-region keep the Ankole long-horned cattle. They have also embraced the application of modern farming technologies and crossbred the Ankole long-horned cattle with Holstein-Friesian cattle to improve milk productivity. Ankole region receives a bimodal rainfall pattern with a peak in April to May and Sep-

tember to November fol-lowed by two dry seasons between June to August and December to February. In a similar manner, pastoralists in Ankole face a scar-city of pastures during the dry seasons des-pite having a bi-modal rainfall pattern the-reby making vegetation dynamics a pivotal issue in the social life of the region (Ros-chinsky et al., 2012b).

Figure 3: Karamoja's seasonal calendar, a typical year



Source: (WFP, 2015)

Economical

From an economic dimension, farm-ing is the major economic activity in the Karamoja region. The region has the highest percentage of people (10%) involved in animal rearing as the main economic acti-vity in Uganda (UBOS, 2018b). This justifies the importance of pastoralism as the main source of livelihood in the region. The eco-nomic progress in the Karamoja region has greatly been undermined by insecurity in the region. Desputses in Karamoja ditch va-rious Karamojong clans and sections into huge conflicts against each other. The conf-licts exhibit themselves in cattle raids bet-ween counties (Odhiambo, 1992). The regi-on also suffers from cross boarder cattle raids emerging from the Turkana and Po-kots of Kenya (IGAD, 2017). Road network is seen to be a critical component in the ar-rangement of actual physical accessibility of any region. For as long as physical access is limited, it remains a great obstacle for rural communities to obtain health, education, and other major social services. Besides, the capacity to make use of any surplus harvest and economic opportunities such as employment within and outside is drastically restrained (Donnges et al., 2007). Residents in most communities (94%) evaluated the nature of local area roads as poor compared to Ankole where only 60.9% rated roads as poor (UBOS, 2018b). This creates more obstacles to the flow of economic activities in the region hence the continuous lag in growth and development. The region has various minerals such as limestone, marble, and gold, which has led tens of thousands of Ugandans to throng to mostly unlicensed, artisanal mining sites to hunt for a living. In the recent past, there has been a great effort by the Ugandan government to promote private investment in Karamoja's mining sector as a way to revitalize development and further enhance security in a district that has languished over many years from conflict insecurity and under-development (Saferworld, 2017). All efforts to stimulate development have not yielded positive results since poverty is highest in the sub-region of Karamoja (60.2%) compared to all other regions of Uganda, and Ankole which is at 6.8% (UBOS, 2018b).

Sociological

From a sociological point of view, Karamoja's population is about 1.2m people. The trend of migration is inclined to Rural - Rural migration (50.1%) with less Rural-Urban migration (16.2%). In comparison with the Ankole region, Rural-Rural mig-ration is slightly lower (45.3%) and a higher rate of Rural-Urban migration (20%) (UBOS, 2018b). The trend of migration in Karamoja can be explained by the continuous no-madism where herdsmen move from one place to another looking for grazing fields and water for their animals. The region has the lowest level of education in Uganda with 51% of the population between the age of 6-24 recorded to have never attended school and only 37% was currently attending school. 59.1% of the population aged 15 and above reported having never had formal education. The education level is better in the Ankole region with 78% of the popu-lation aged 6-24 currently attending school and only 20% reported to have never atten-ded school. Only 14.6 of the population aged 15 and above reported to have never had formal education (UBOS, 2018b). The edu-cation level in Karamoja is directly related to the continuous Rural-Rural migration and way of life where the youths spend most time herding rather than going to school. Karamoja also has a great section of the po-pulation with limited access to healthcare services with 17.2% of the population ha-ving to move a distance of over 5 kilometers to access first treatment as opposed to An-kole where this applied to only 15.2%. Rural communities in Karamoja struggle with ac-cess to food as the food available for human consumption stands at 1,986 kilocalories per person per day compared to Ankole where the average food consumption is 2,463 kilo-calories per person per day. In general, Ka-ramoja has the highest food poverty rate at 70% compared to Ankole at only 14%. Furthermore, it was also observed that sett-lements in Karamoja are mainly made up of semi-permanent structures that are grass thatched (89%), whereas, in Ankole, the establishment of permanent structures has been appreciated with 96.3% of the hou-seholds using iron sheets for roofing (UBOS, 2018b).

The pastoral culture of the Karamo-jong people has a strong connection and inf-luence on the sexual and reproductive health of the community. Regularly, cattle are viewed as a fundamental prerequisite for the family, and its growth through marriage (Muhereza, 2010). Females seek to be offi-cially married with cows as bride price as this grants them acknowledgment to be part of the spouse's family, clan, and faction (Stites et al., 2007). This need can impact juvenile young ladies and adolescents to observe and spot admirers who are well off, in order to have a complete marriage status. Further, this community is tolerant and non-restrictive; young ladies can engage in sexual relations with men who mean to wed them. Regularly, this is unprotected sex. This is especially so as a direct result of the cultural norm of bride capture where a man engages in sexual relations with the young lady to show his aim of marriage. Nonetheless, this norm might bring about early pregnancy and contracting STIs through unprotected sex by both females and males (Achen et al., 2021). Most families in Karamoja are poly-gamous in nature. This is because polygamy is culturally

accepted in the community. On the other hand, family life in the Ankole re-gion is somewhat different from that in the Karamoja region. Karamoja region was reported to have more polygamy families with at least 36.3% and 21.9% of married ladies revealing that they had one and more than two co-wives respectively whereas in Ankole figures stood at 12.8% and 1.8% for one and more than one co-wife respectively (Uganda Bureau of Statistcs (UBOS) and ICF, 2017).

SWOT analysis

From the SWOT analysis results in table 1, Karamoja's most significant streng-ths lie in the strategic location at the border, well-adapted breeds of cattle, the communal land tenure system, and the bonding social-cultural traditions. The most outstanding weaknesses include; cultural rigidity, internal cattle rustling, a location that is far away from better markets, poor infrastructural development, and the Uni-modal rain pattern that hinders agricultural production.

The major threats to the region are the negative impacts of climate change and external cattle rustling from nomadic pastoralists (Pokot and Turkana) of Kenya.

Based on the Ecological, social, and SWOT analysis, it is evident that Karamoja faces several development challenges, ke-eping the region in extreme poverty for de-cades. On the other hand, Ankole faces somewhat similar challenges but has suc-cessfully broken the locks of poverty and made significant strides towards rural deve-lopment. Given the fact that both Karamoja and Ankole are pastoral regions, a compari-son in terms of differences and similarities is critical if lessons are to be learned from An-kole's progress.

Table 2 summarizes the results with a key similarity of both regions having more population in the rural areas with less Rural-Urban migration but more mobility within the rural areas in form of Rural-Rural migration.

Table 1: SWOT Analysis of Karamoja Region

	Strengths	**Weaknesses**
Internal Factors	• The traditional social-cultural life is more binding offering a possibility for economic collaborations in form of SACCOS and Cooperatives. • Based on the communal land tenure system in the region (Rugadya, 2020), there is limited land fragmentation which can be capitalized on to enhance intensive farming. • Karamoja is strategically located at the border with better access to both inputs and markets from the neighboring countries of South Sudan and Kenya. • The Zebu cattle mainly Kept in Karamoja are well adapted to harsh climatic conditions with high temperatures. This has enabled the continuity of pastoralism in the region amidst climate change challenges. • Wide Mineral resource base.	• Cultural rigidity has hampered the development of the livestock sector due to continuous pastoralism and keeping of indigenous less productive cattle breeds. • Poor accessibility; poor rood network, makes access to better markets in Kampala and other districts difficult. • The Uni-modal rain pattern in the region poses great challenges to crop and pasture production hence the increased rate of pastoralism. • Internal Cattle Rustling: Karamajongs continue to raid cattle among themselves causing insecurity in the region and hindering the development of livestock production in the region. • Poor infrastructural development in the region hinders economic activity.
	Opportunities	**Threats**
External Factors	• Under proper organization, farmers in the regions have a better chance to compete for government subsidies compared to any other region in the country. This is because less pastoral regions have been prioritized under the Regional Pastoral Livelihoods Resilience Project (RPLRP) (MAAIF, 2014).	• External Cattle Rustling: Following a disarmament project in Karamoja by the government of Uganda, The Pokots from neighboring Kenya easily attack the defenseless herdsmen stealing all their cattle. • Karamja's location along the border with Kenya and South Sudan renders the region prone to conflict spillovers from both regions' likely internal conflicts

Source: Own editing

Table 2: Similarities and differences between Karamoja and Ankole Rural regions

Differences	**Similarities**
• The levels of poverty and extreme poverty faced by Karamoja are extremely high; unlike Ankole where poverty levels have progressively dropped over the years. • In Karamoja, there is limited access to social services such as schools, hospitals, and roads as opposed to Ankole where access is better. These are not only vital for the social wellbeing of the people but also the acceleration of economic activities in the area. • Karamoja has acute food insecurity; unlike Ankole where the majority of the population can easily access enough food daily. • Unlike Ankole which has progressively had stable security, the Karamoja region has had a lot of insecurity mainly caused by cattle rustling both from within the region and by external nomads from Kenya (Kugonza et al., 2012; MAAIF, 2014; Närman, 2003).	• Both Ankole and Karamoja rural areas depend on agriculture as the main economic activity with livestock production dominating. • Rural-rural migration is more common in both regions compared to Rural-Urban Migration. • There is a great effort by the government of Uganda to promote sedentarization policies for better economic productivity and minimization of environmental damage to the environment in both regions. • Both regions suffer from invasion by crop and livestock pests and diseases, which greatly reduce the production and profitability of the agricultural sector in the rural areas. • In both regions, cattle rearing is not only an economic activity but also considered part of their heritage, with one's wealth and social status determined by the number of cattle owned.

• The impacts of climate change have negatively affected Karamoja's population which is profoundly reliant upon means subsistence farming, that is sensitive to changes in environmental conditions, making farming a risky survival mechanism rather than Ankole where climate change impacts have not been so tremendous.	• Both regions are located in the Uganda cattle corridor.

Source: Own editing

RECOMMENDATIONS AND CONCLUSIONS

Karamoja is a semi-arid area with numerous climatic challenges but also has a range of minerals that can boost the economy if put to the right use. To achieve development in the area, there is a need for a collective effort from the government, civil society, and the community to improve the road network, education, health care, Agricultural markets, and other social amenities vital in propelling economic activities.

The SWOT analysis indicates that there are several strengths as well as opportunities that can be capitalized on to improve rural development. Unfortunately, the social and economic indicators present several challenges to the way of life and economic development of the region.

From the comparison between Karamoja and Ankole pastoral regions, both have a long history of pastoralism. However, the Ankole region has progressively adopted sedentarization as opposed to Karamoja where most communities still practice nomadic pastoralism.

The information analyzed also reveals higher poverty and food insecurity levels in Karamoja as opposed to Ankole. These are attributed to the dry climatic conditions in the area that do not favor agricultural production. Climate change mitigation and coping strategies need to be undertaken to improve agricultural productivity in the area. Measures that can be undertaken include; the planting of trees, climate-smart agriculture, and the use of irrigation.

The ministry of Karamoja affairs should be given more funds to carry out intensive research to develop specific policies and projects with practical solutions to rural development challenges in Karamoja.

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THE INDUSTRIAL 4.0 REVOLUTION: CAN IT POSITIVELY STEP INTO SUSTAINABLE HOSPITALITY?

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Abstract: *Technological advancements recently affected production, social and sustainable development. Few publications have addressed the industry 4.0 contribution to the sustainable hospitality industry. In this study, we review the ways and effectiveness of industry 4.0 in achieving sustainable development goals in the hospitality sector. Due to the modernity of the issue, resources used in this paper included articles from databases like SCOPUS, Sage, Elsevier, and Google scholar using keywords such as big data analytics, simulation, Artificial intelligence, Industry 4.0 in hospitality, sustainable hotels, industry 4.0 adaption in hospitality and smart hospitality system. This literature paper outline has five main sections—section one introduces industry 4.0. Section two is a literature review that includes industry 4.0 connotation, Industry 4.0 elements, features and drawbacks. Regarding material and methods, this literature review was conducted using articles from online databases from 2016 to 2021. The primary output of this paper is Table.1, which summarizes the most critical components of advanced technology that can aid in achieving sustainable development goals in the industry, followed by the conclusion.*

Keywords: *Industrial revolution 4.0, Industry 4.0 impacts, Industry 4.0 pros and cons, Hospitality sustainability.*
(JEL classification code: L83)

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INTRODUCTION

The term 4.0 industry has become a necessary topic recently. The fourth industrial revolution is changing the way we live and work. The business and industrial landscape have changed drastically, resulting from advanced technology developments and innovations. (Pereira & Romero, 2017; Tsvetkova, 2020; Zengin et al. 2021). Industry 4.0 has different terms as it is still in the early phase. As an illustration, in a medical speciality, it is defined as a way of human life transformation, whereas, in economics and businesses, it is considered a way of enhancing economic and business growth. The umbrella of the fourth industrial revolution concludes the recent technological advancements as follows; Cyber-Physical Systems (CPS), Internet of Things (IoT), Internet of Services (IoS), Robotics, Big Data analytics (BDA), Cloud Manufacturing, and Augmented Reality (Pereira & Romero, 2017; Verevka, 2019; Zengin et al. 2021).

Fundamentally, the 4.0 industry has a significant impact on nature and humankind. Consequently, sustainable development in the industrial revolution epoch has become a topic for debate. Sustainable development (SD) can be defined as a recent idea of serving people's needs without harming the planet's current condition (Tsvetkova, 2020).

Shamim et al. (2017) ensured that a considerable amount of literature had been published on addressing the 4.0 industry related to customer reaction, work environment enhancement and cost reduction. Research in sustainability and digitalization in the hospitality sector is in its infancy, and the contribution of the industrial 4.0 revolution to sustainable hospitality is controversial and needs further exploration (Ghobakhloo, 2020). Surprisingly, sustainable development in the hospitality industry is seldomly studied, and it is unclear to what extent the 4.0 industry revolution can be harnessed to achieve sustainability goals in this sector.

Consequently, this paper evaluates the ways and effectiveness of industry 4.0 in achieving sustainable development goals in the hospitality sector.

LITERATURE REVIEW

Industry 4.0 connotation

Recently, there has been renewed interest in sustainable development in the hospitality industry. Industry 4.0 can play an essential role in addressing the issue of the sustainable hospitality industry. The fourth industrial revolution can be defined as the digital transformation in businesses and processes (Müller, 2019). Cyber-physical systems (CPS) and smart production are the main features of industry 4.0 implementation (Shamim et al. 2017). In the same vein, Koo et al. (2021) mentioned that industry 4.0 is an area of computer science that replaces humans in performing tasks to enhance business efficiency.

Industry 4.0 elements

The first industry 4.0 element is Artificial intelligence (AI), described as intelligent machines acting and working as employees. Turning into Augmented reality (AR), a displayed environment based on reality encloses computer effects' features to foster the real-world experience. It works as a bridge between gathered data and virtual reality to analyze, aim to redesign and repair products or services. Another feature is that it improves problem-solving skills, expands options for upgrading products and services, and helps customers get their desired products by displaying each product and service specifications. Robotics is an element that performs repetitive tasks in manufacturing and business. Big data and analytics are also practical 4.0 elements harnessed to analyze massive data incapacitated from traditional approaches. It is characterized as a transformation point of understanding, producing, selling, level of innovation, predictions Etc. Cloud refers to cloud computing providers and any services provided by them. An essential feature of the cloud is integrating services, cutting IT expenses, and fast-lane business (Moktadir et al. 2018; Bai et al. 2020; Szabó-Szentgróti et al. 2021; Zengin et al. 2021).

Internet of Things (IoT) is a set of hardware that work together within IoT to enhance the operations and processes at the workplace. It can be applied in various specialities, manufacturing, agriculture, mining, transportation, healthcare, service industry Etc. Sensors and actuators: A device with a sensor receive a physical stimulus to control things like heat, light, and sound systems. Mobile Technology is the integration of technology-based devices working wirelessly. Global Positioning System (GPS) group of satellites allows GPS to identify users' location, speed, and time. Cybersecurity provides a high level of information protection from hacking which affects brands, designs, creation, and product manufacturing. Simulation is a technology that simulates the real world and system targeting new product support. Prototyping and automation increase efficiency and improve production quality (Moktadir et al. 2018).

Advantages and disadvantages of Industry 4.0

Pereira and Romero (2017) and Moktadir et al. (2018) mentioned that the fourth industrial revolution has tremendous improvements in production, service processes, manufacturing systems and quality, offering new business models, new operating ways, strengthening stakeholder relationships, market and marketing influences and increasing competition. Bai et al. (2020) identified several features of industry 4.0. A profitable business model is one crucial merit followed by efficiency, quality, and work conditions enhancement.

In contrast, the common disadvantages are the shortage of understanding, costs, work environment system changes and adaption. Although the technological advancements pros mentioned above, there are cons; a big concern arises when humans do not work to earn money, leading to unemployment, poverty, and air pollution, which is against the sustainability goals. Moktadir et al. (2018) and Szabó-Szentgróti et al. (2021) ensured that industry 4.0 carries out cons such as insecurity of data, technology infrastructure is costly, unstable companies' connectivity, unemployment, environmental impacts, managers' strategies towards new changes, and lack of management and employees' skills.

The importance of sustainability development in various specialities has arisen from this point. Therefore, this paper reviews harnessing industry 4.0 to achieve sustainable development in the hospitality sector because it is one of the service sectors affecting the core dimensions of sustainability (Coupe, 2019).

MATERIALS AND METHODS

To understand how industry 4.0 shares in sustainable hospitality positively, a comprehensive literature review has been done based on databases and journal articles, which are secondary data sources. Moreover, this review research was conducted considering the following online databases: Elsevier (Science Direct), Scopus, Emerald Insight and Springer, over the 2016-2021 timeframe. This paper's objective consisted of (1) identifying the main articles in this regard to review different perspectives on this issue to reflect whether industry 4.0 can step in the Sustainable hospitality industry positively or not, (2) the analysis of each industry 4.0 element role to achieve sustainable hospitality goals.

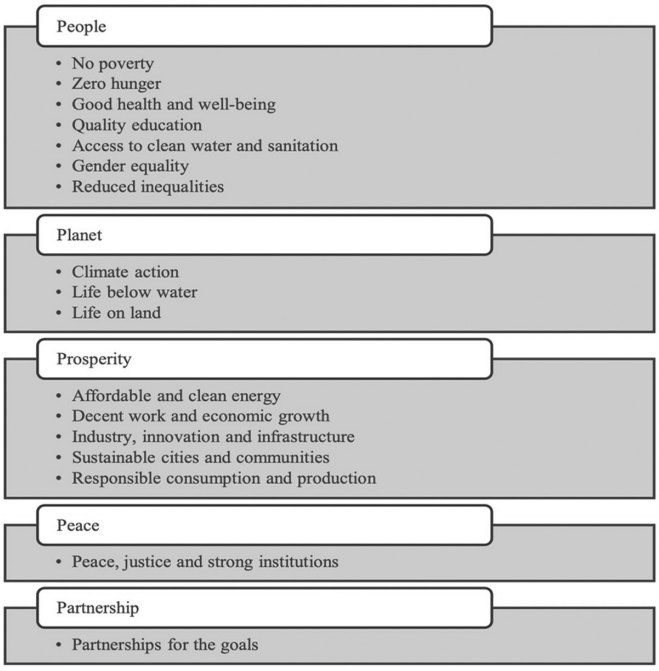
RESULTS AND DISCUSSION

Sustainable development overview and goals

Tsvetkova (2017) reflected that sustainable development (SD) preserves the planet's condition while living, working, and developing. United Nations stated that the best definition for sustainability is to enhance well-being for all, the next generations no exception, which means solving global issues such as injustice, inequality, peace, climate change, pollution, and environmental distortion and degradation; these issues were divided into three pillars environmental, economic, and social sustainability including 17 goals (Stock et al. 2018; Ghobakhloo, 2020). This study defines sustainable development as doing life activities without harming current planet conditions.

There are several ways to identify SD goals, but the UNs' General Resolution and Agenda is internationally approved. The UN tabled the main 17 goals to ensure sustainability, including the broad goals of ending poverty, protecting the planet, and guaranteeing prosperity (Figure 1).

Figure 1: The UNs' 17 goals



Source: Tsvetkova (2017).

Challenges of achieving sustainable development goals

Tsvetkova (2017) reflected that sustainable development (SD) preserves the planet's condition while living, working, and developing. United Nations stated that the best definition for sustainability is to enhance well-being for all, the next generations no exception, which means solving global issues such as injustice, inequality, peace, climate change, pollution, and environmental distortion and degradation; these issues were divided into three pillar

Industry 4.0 as possible solutions for sustainability challenges generally

Industry 4.0 has the interconnectivity feature; that is why most of its elements would be considered a possible solution for sustainable development challenges (Berawi, 2019). Looking at robotics can create options and ease decision-making by providing virtual reality. A much clearer picture of goals is provided by Augmented reality. It also helps governments plan and performs with a few shared human resources. Big data analytics can perform unlimited opportunities for gathering and analyzing data. It can specifically solve the need for more access to information and unified standards.

Furthermore, it can integrate with virtual prototyping to prioritize the SD goals based on the current situation. System integration expands governments' capacities, combines data with complementary, and leads to criteria unification. Cloud technologies provide a vast range of unification, awareness, raising, spreading, processing information, cost-saving, and improving capacity (Pereira & Romero, 2017).

Industry 4.0 for a sustainable hospitality industry

The hospitality industry changes in the environment are significant through food consumption, Co2 emissions, waste, water and electricity usage, construction activity and land use; that is why addressing sustainability plans in the hospitality industry has become a crucial issue (Nadkarni et al. 2020).

On the other hand, the hospitality industry is one of the service industries affected by AI, robotics, big data, CPS, the IoT, AR, and VR, which are aspects of the industry 4.0 revolution. The industrial 4.0 revolution is a step into hospitality sustainability as it is environmentally friendly, and it contributes to achieving sustainable development goals such as energy and water efficiency, food waste reduction and reducing air pollution (Bartodziej, 2017; Tsvetkova, 2017; Buhalis and Leung, 2018; Buhalis et al. 2019; Nadkarni et al. 2020; Nayyar & Kumar, 2020). The way each industry 4.0 element contributes to hospitality sustainability is summarised in the following table.

Table 1. The ways Industry 4.0 can step into the sustainable hospitality industry

Author	Industry 4.0 element	How it Contributes to sustainable hospitality?	Sustainable development pillar
Bartodziej (2017) and Nayyar and Kumar (2020).	Cyber-physical systems (CPS)	It provides the feature of analytics, computational capability, and data management smartly. Additionally, access to real-time data is based on the interconnection between the physical and cyber worlds.	Environmental pillar.
Buhalis, and Leung (2018) and Nadkarni et al. (2020).	Internet of things (IoT)	Enables connection with guests, gathers data, establishes profiles for each guest with their preferences, and evaluates their behaviour and performance. It can share a 10% reduction in food consumption, Co2 emissions, waste, water and electricity usage. IoT helps with sensors in in-room consumption by light and climate control. Devices are supplied with the feature of decision-making for energy saving. For instance, when guests leave the room thermostat can be active in energy-saving mode.	Environmental and social pillars.
Tsvetkova (2017) and Buhalis, and Leung (2018).	Augmented Reality (AR)	It enhances personalized service experiences with additional features. Guests could share their experiences, opinion and information within a network.	Social and economic pillars.
Nayyar and Kumar (2020).	Virtual Reality (VR)	People can travel via virtual reality, which encourages cost reduction and contribute to Sustainable development (SD). It provides new patterns for tourists to travel to a destination instead of mass tourism which causes environmental pollution. People can visit museums, castles and tourist places and destinations before travelling physically in virtual reality. This would help in mass tourism reduction. The main issue is tourists' perception and satisfaction with using it as a substitute for actual travel and presence. These two factors mean that mass tourism will not be resolved unless consumers accept and know the value of sharing in this process.	Environmental and social pillars.

Moktadir et al. (2018).	Big data analytics (BDA)	It saves internal and external big data and classifies data based on properties. Data can be used to improve the strategic planning and managing operations in proportion to the ecosystem, which serves sustainable development goals at the core of environmental respect and commercial success. Previously, limited storage capacity has led tourism companies to delete old data. This cannot happen today, thanks to Big data analytics. Big data analytics allows data transformation and gathering. The importance of data comes from the benefits of these data in identifying customer patterns, targeting customers, experience creation, and offering customized service. Big data analytics allow the hospitality sector to build a relationship with customers and update them with the changes in hotels, restaurants and touristic destinations regarding new applied patterns which serve sustainable development goals and how to help in that by indicating the necessity of customers' share.	Environmental and economic pillars.
Buhalis and Leung (2018).	Artificial Intelligence (AI) and robots	It provides outstanding personalized service. As a good example, information canters at airports and hotels.	Social and economic pillars
Nayyar and Kumar (2020).	Sensors and actuators	Sensors and actuators are used in lighting, temperature adjustment, showers, sinks, laundries Etc, targeting energy and water savings and reducing bills. Smart meters in hotels and restaurants kitchens would help save food waste.	Economic and environmental pillars.
Buhalis et al. (2019).	Smartphones	It contributes with a feature of identifying customers' dishes preferences, purposing provide the right portion size and reducing waste.	Economic and Environmental pillars

Source: authors' editing

CONCLUSION

Advanced technology influences every single day we live—the awareness of the industry 4.0 revolution increases in all industries, including the hospitality industry. Many questions related to industry 4.0 in the hospitality sector have been raised, especially concerning how to harness it in serving business needs and make its adaptation effective in serving employees, consumers, and the environment. This paper aims to discuss how industry 4.0 can step into sustainability in the hospitality sector to bridge the gap in the literature review. It sheds light on reviewing the main advanced technology elements that can share with sustainable development cores in this sector (Table 1). This paper gathered the advanced technology elements useful for sustainable hospitality development from several studies to enlighten the hospitality industry players about one of the bright aspects of applying modern technology. Additionally, it guides hospitality players on how modern technology addresses sustainability challenges and helps them pick up the right technology elements to serve SD goals. Future studies can focus on an in-depth investigation of each advanced technology element's role in hospitality sustainability.

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A MATRIX MODEL FOR INTEGRATED PEST MANAGEMENT AS A COMBINED FUNCTION OF EXTENSION EDUCATION AND ECONOMIC CONCEPTS: SCIENTIFIC NOTE

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Abstract: *The Farmer Field Schools (FFS) help to establish the significance of the Integrated Pest Management (IPM) concept, i.e., the FFS contributed to demonstrating the importance of the IPM idea. In this paradigm, the integrated pest management specialist's decision is based on the application of agricultural extension and economic principles. This requires an analysis and understanding of the ecosystem and plant physiology, followed by monitoring the population dynamics of the pest to determine the pest's economic injury level, and finally, determining the appropriate action to suppress it. The transition point from organically integrated pest control measures to chemical pest control is when pest density exceeds economic injury. In other words, when pest density surpasses economic damage, an organically integrated pest control approach gives way to the chemical pest control method. This study advises conducting research experiments and studies to ascertain the economic impacts of pandemic pests on the targeted crop, such as powdery mildew and aphid pests in the protected tomato plant culture.*

Keywords: *Economics, Extension, Integrated Pests Management*
(JEL code: Q16)

INTRODUCTION

Plant health professionals should implement integrated pest management (IPM) strategies. The implementation of IPM is divided into two sections, it is a two-part approach. The first approach incorporates all the procedures before the pest population intensity level reaches an economically significant threshold (ET). The second section/approach is based on the use of chemical pesticides when the economic injury level (EIL) is exceeded. The integrated pest control expert should create a model incorporating agricultural extension skills and economics. The proposed model considers economic concepts and is the primary motivator for an extension expert in integrated pest control to select an extension technology to prepare farmers for adoption.

(MASSIMI et al. 2021) stated that the integrated pest management philosophy is a new form of an agricultural extension developed by the World Food and Agricultural Organization (FAO) under the name of Farmers' Field Schools (FFS). Farmer field schools and integrated pest management are extension projects that deal with the management of technology transfer, training and development techniques. Transfer of technology refers to the entire process of developing, processing, disseminating, and integrating technology through research, extension, and farming systems while keeping in mind the society's resources, organizational limitations, and abilities to solve problems. On the other hand, training is concerned with imparting skills for specific purposes. It is the process of educating growers to make them fit, qualified, and proficient in performing a specific task. Development refers to the direction of change instilled in employees through the training and education process (KARTHIKEYAN et al. 2007). This scientific note attempted to create a model in agricultural extension for plant protection and integrated pest management experts using a farmer field school framework.

The concept of intensive agricultural horticulture contributes to the significance of this model. The ability to maximize crop yield and profit per unit area in a relatively short time is the defining feature of intensive horticulture. The Rural Planning Project Queensland Farmers' Federation (QFF, 2015) has documented a close definition of the economic investment and protected horticulture segments. However, intensive horticul-

ture in developing countries showed the widespread use of chemical pesticides, chemical fertilizers, exogenous growth regulators, and early mature varieties. Intensive horticulture is protected under optimal environmental conditions. Due to space and time constraints, crop rotations are not possible in intensive horticulture. The same scientific source mentioned above contradicts the current paper's opinion that intensive horticulture does not use chemical pesticides. This may sound true, but not in developing countries, at least.

According to the Entomological Society of America (handbook of soybean insect pests), both economic injury level and economic threshold are defined as follows (HIGLEY and BOETHEL, 1994):

1- Economic injury level: "the smallest number of insects (amount of injury) that will cause yield losses equal to the insect management costs".
2- Economic threshold: "the pest density at which management action should be taken to prevent an increasing pest population from reaching the economic injury level".

EILs are typically expressed as a pest density and are derived from yield-loss relationships discovered in field research studies. The EIL has been described as the break-even point and the level of pest a plant can tolerate. The main goal is to manage the pest population before it reaches the EIL. This is where the ET enters the picture. The ET is a practical rule that is used to determine when management action should be taken. The ET is sometimes referred to as the action threshold. The limiting imaginary line between the two levels is the boundary between intensive gardening based on chemical treatments and other protection measures such as prediction, preventive practices, and technical, physical, and biological control tools.

To illustrate the economic concepts, consider the powdery mildew disease on cucumbers. Powdery mildew caused by Sphaerotheca fusca was studied on cucumbers to determine the economic injury level and yield response. The economic threshold was determined by grading the disease severity of powdery mildew based on the relationship between disease severity and yield response. Cucumber yields were reduced overall as disease severity increased. As a result, the presence of powdery mildew harms cucumber yield. Y= -57.237x+6143.1 was found in the regression equation between disease severity and yield loss. Based on yield and economic relations, this equation suggests that the disease severity of the economic threshold is 17.6 %, which is a 3% reduction point of yield. These findings suggest that fungicide should be applied when 1 or 2 cucumber leaves are infected with powdery mildew in the growing season (KIM et al. 2006).

Soybean aphids serve as another instance of economic issues being illustrated. (RAGSDALE et al. 2007) found that the average economic threshold (ET) was 273 ±38 aphids per plant of soybean. This ET provides a 7-day lead time before aphid populations are expected to exceed the EIL of 674± 95 aphids per plant. Soybean aphid, Aphis glycines Matsumura (Hemiptera: Aphididae), reached damaging levels in most northern U.S. states and Canadian provinces in 2003 and 2005 in soybean, Glycine max (L.) Merrill, and has become one of the most important pests of soybean throughout the North Central region.

The goal of this scientific note is to create a model that integrated pest management experts can use. By combining the concepts of agricultural extension and pest population economic levels. This model can be applied to a variety of pests that infect crops. Particularly in intensive horticulture. An integrated control program for powdery mildew and aphids on tomatoes will be proposed.

METHODOLOGY

This scientific note is based on the steps outlined below:

1- The scientific concepts of agricultural extension and agricultural economics were converted to smart diagrams and graphs (Figures 1-3) using a set of academic references (MASSIMI et al. 2021) and (HIGLEY and BOETHEL, 1994) and Microsoft Excel Spreadsheet Software (Microsoft 365).
2- A bio-ecological description of tomato plants in protected cultivations is being presented (different stages of development, as well as ideal temperatures and relative humidity) (Table 1).
3- Powdery mildew (*Leveillula taurica*, and *Oidium neolycopersici*) and aphids (*Aphis gossypii*, and *Myzus percisae*) were chosen for this study. Under favorable environmental conditions for tomato plant growth, the likelihood of the emergence of these pests is extremely high.
4- These two pests have been targeted with integrated pest management (IPM) suggested protocols. All possible controls (forecasting, preventive, technical, physical, biological, and chemical) are considered, assuming imaginary economic levels.
5- This scientific note is not based on research or experimental evidence that establishes economic thresholds for specific pests. But this study is significant for academics because it focuses on how to integrate extension and agricultural economics concepts within IPM frameworks.

RESULTS AND DISCUSSION

Integrated pest management, integrated plant protection, or integrated crop production is a program and a set of steps that can be used to combat any pest, beginning with technical methods, and progressing to physical, biological, and finally chemical methods. Chemical control is the last remedy after all other methods have failed to control the pest. Mulch, for example, is used as a technical control, deep ploughing is used as physical control, and natural enemies are used in biological control. Through an integrated analysis of the agroecological and biological systems, an integrated pest management program for any pest can be prepared.

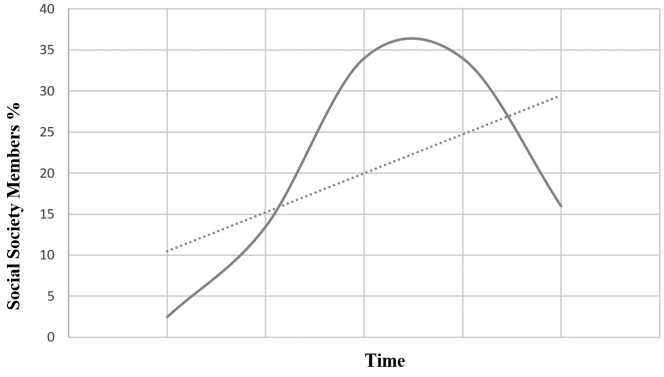
The agricultural extension follows a specific mechanism to implement any control technique based on the various segments of society. The curve in Figure (1) depicts the normal distribution of rural community segments in terms of innova-

tion adoption. Over time, as technology is adopted, the proportion of community members (social system members) is divided into the following types and proportions:

- 2.5 % are innovators.
- 13.5 % are early adopters.
- Early majority is 34%.
- 34% have a late majority.
- 16 % laggards.

Any technology takes time to be adopted and spread because of the surrounding environment and the needs of the rural community. The time indicated in Figure (1) is speculative (varied) and not standard.

Figure 1: The normal distribution curve of social system adoption of chemical pesticide innovation



Extension projects are classified into extension programs and farmer field schools. Field schools for farmers are more focused on plant protection and integrated pest management. Farmer Field Schools (FFS) is an extension project developed basically by the Food and Agricultural Organization (FAO) and its agricultural extension aim to:

1- Grow healthy crops.
2- Maintain natural enemies
3- Promote field monitoring.
4- Develop expert farmers.

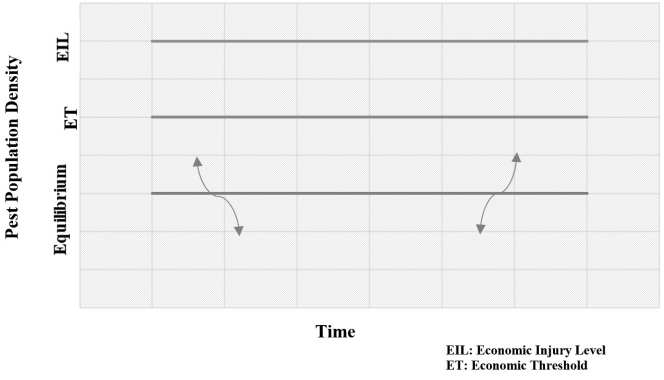
The following are examples of protocols of plant protection methods used in the farmer field schools:

- Preventive methods by plant protection forecasting based on environmental records and agricultural practices such as growing pests-resistant varieties, and foliar nutrition (before infection as a preventive practice).
- Agri-technical techniques such as reduced tillage, using of mulch, foliar nutrition (both as a preventive practice or for treating infections), and irrigation modeling.
- Physical and mechanical means of pest control, such as soil cultivation for weed control.
- Biological control, such as plant-derived bio-herbicides, biological pesticides, natural enemies, and parasitoids.
- A chemical, such as GPS-based chemical spraying and seed dressing chemicals.

Figure (2) explains the economic threshold concept as the number of insects per plant or the amount of damage caused by the pest that justifies the use of control measures economically. Controlling a pest population before it reaches the economic threshold will suppress the population before it reaches the economic injury level. The goal of integrated pest management is to keep pest populations below the level that causes economic injury level. The level of economic injury is reached when the cost of pest control equals the revenue loss caused by a pest. It is calculated by estimating the potential yield loss, crop value, and treatment cost. Figure (2) also indicates natural enemies balance pest population equilibrium (chemical control is not needed at this level). In another sense, the level of balance of natural enemies with the density of the pest necessitates only biological and organic control. It is worth noting that agricultural extension can direct producers to use primary methods of control such as preventive, technical, mechanical, biological, and organic protocols at this level and before reaching other economic levels.

The pest's damage can be avoided at the economic threshold level (ET). Control is vital at this level. An integrated and diverse protocol of integrated pest management approaches can be used, keeping in mind that the chemical solution is the last option in the incident that the previous methods of control fail (Figure 2).

Figure 2: Various pest levels on the crop during the agricultural season

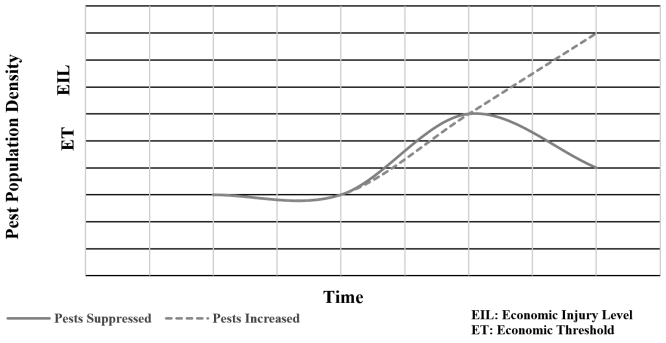


If the integrated control schedule failed to eradicate/suppress the pest development and the pest density reached the maximum (economic injury level), the damage can be considered done at that time, and it is also late to take action to control the pest (Figure 2).

If integrated control methods fail to prevent the pest from expanding, the pest population's density will deviate from the normal distribution and continue to grow until it exceeds the economic injury level (EIL) (Figure 3). The level of economic injury is reached when the cost of pest control equals the revenue loss caused by a pest (i.e., financial return savings by control). It is determined by assessing the potential yield loss, crop value, and treatment cost. The cost usually represents the cost of chemical treatments whereas other integrated control methods are regarded as relatively inexpensive. Before pest levels reach the critical economic level (EIL), non-chemical integrated control methods are economically profitable in

terms of crop yield production and profits. Pesticide chemotherapy is not financially viable at this stage. Given that the benefit from the use of chemical pesticides is very small due to the risk factors of pesticides on humans' health, animals, natural enemies, and natural resources. In this case, the agricultural extension advisor must use integrated pest management and should only use chemical control as a last resort (after other means of control fail in the elimination of pests).

Figure 2: Various pest levels on the crop during the agricultural season



In contrast, if the pest's density exceeds the level of economic injury, the cost of chemical control becomes less than the benefits (in other words, the damage due to the pest is economically higher than the cost of chemical control). The use of chemical control is required at this stage. If an agricultural extension agent is in a similar situation and employs the integrated pest management method, he or she must make a chemical control decision right away (Figure 3).

Based on the foregoing, an integrated control program for tomatoes will be stated. Particularly in the case of powdery mildew and aphids. Tomato (Lycopersicon esculentum Mill.) is a summer crop that grows, develops, and produces best in warm weather. Temperature, light, and relative humidity are all factors that influence crop success. (ZEIDAN, 2005) detailed the most important climatic factors for tomato germination, growth, and production, such as heat and humidity. According to the reference, this data is shown in Table (1).

Consequently, any expected or unexpected temperature and relative humidity extremes will directly affect growth and production, as well as indirectly by adapting the ideal conditions for the spread of pests such as fungi, insects, and weeds that attack the crop.

To develop hierarchical and sequential plant protection protocols, it is critical to examine the tomato crop's ecological and biological system within integrated pest control strategies. Environmental variables can be used to create prediction models for pest control and management.

Table 1: Tomato temperature and relative humidity requirements in different growth stages

Growing Stage	Minimum temperature (℃)	Optimum temperature (℃)	Maximum temperature (℃)	Relative humidity (%)
Germination	11	16-29	34	
Growth	18	21-24	32	65-85
Fruit set at night	10	14-17	22	
Fruit set at day	18	23-26	32	
Chilling injury		6		
Frost (Freezing)		-2 - -1		

Source: Zeidan, O. (2005). Tomato production under protected conditions.

Plant protection techniques are currently heavily reliant on integrated pest management, which entails monitoring plant health in terms of nutrition, irrigation, and autoimmunity, as well as developing a plant with a genetic composition that interacts positively with environmental conditions, enhancing growth and production while avoiding physiological, environmental, and biological stress factors.

Disease and pest management consumes a sizable portion of tomato production costs (ZEIDAN, 2005). Pesticides have become less common in recent years for a variety of reasons, including:

1- Cost-cutting in the production process.
2- Toxic residues on fresh fruits and vegetables (crop products) are avoided.
3- Prevention of air pollution of environmental components (air, water, and soil) and environmental damage.

Other reasons such as:

4- Protection of natural enemies and other non-target species
5- Reducing increased pesticide resistance.

Projections for plant protection emphasize the importance of integrated pest control protocols as a current scientific strategy for reducing the use of manufactured chemical pesticides. The application of synthetic chemical pesticides is critical to IPM's final control option. It is strongly recommended that extension agents use an organic IPM program (MULVIHILL, 2021).

Powdery Mildew (Leveillula taurica, and Oidium neolycopersici):

The following environmental factors are critical for forecasting the infection of tomato plants with this fungal pathogen:

1- The high relative humidity is ideal for infection to begin, and infection can occur at humidity levels of 50%, and temperatures ranging from 10 to 32 ℃.
2- Disease development, as well as the formation, reproduction, and distribution of spores, benefit from dry circumstances.
3- The ideal temperature for the disease to develop is between 20 and 27 ℃. (DOUGLAS, 2003) stated that maximum disease development occurs at temperatures below 30°C.

So, based on signs and predictions of the existence of powdery mildew disease in tomatoes, a model of integrated pest management of this pathogen can be created in the following sequence:

1- Because powdery mildew pathogens can hibernate or overwinter in buds and plant residues during the winter, removing previous crop remnants from the field is critical.
2- Select drought and powdery mildew tolerant cultivars in collaboration with scientific research, professional agricultural extension, and concerned enterprises.
3- Proper greenhouse ventilation is required during the seedling and vegetative stages of plant growth and the implementation of a regular irrigation program to avoid the appearance of drought impact symptoms.
4- The foliar nutrition technique is one of the means of organic integrated pest control, and some non-formal scientific reports are indicating that spraying tomatoes with a solution of sodium bicarbonate (NaHCO3) can eliminate powdery mildew pathogen, as it is recommended to make a homogeneous solution of (10 to 15 gm L-1) and sprayed it once a week on plants.
5- It is highly recommended as a last resort to spray chemically with manufactured fungicides of a special type for the powdery mildew disease if the infection surpasses the economic injury level. Chemical fungicides should be applied differently from season to season to avoid the emergence of resistant strains.

Aphids (Aphis gossypii) and Green Peach Aphids (Myzus percisae):

Tomatoes can be affected by two different species of aphids: Aphis gossypii, and Myzus percisae. Aphids have sucking mouthparts that pierce plant leaves, stems, and roots to drink the sap. As a protection measure against predators, aphids leak waxy material from their cornicles (MULVIHILL, 2021). Honeydew, a sugary liquid excreted by aphids, attracts ants, who consume it and defend the aphids from predators. The season for aphids is all year, and they reproduce a sexually. It eats leaves that curl because of this. Potato virus Y (PVY) and Cucumber Mosaic Virus (CMV) are transmitted by aphids (ZEIDAN, 2005). Clusters of little insects on the undersides of leaves, honeydew, yellow or curled leaves, reduced growth, and malformed buds are all indications of aphid infections (MULVIHILL, 2021).

Integrated control compromises a variety of agricultural strategies (NCARTT and GTZ, 2001):

1- Agricultural (both preventive and technical) methods:
  1.1- Avoid using too much nitrogen fertilizer.
  1.2- Grow healthy seedlings, which are free of the insect.
  1.3- Cover the soil with plastic silver mulch.
2- Mechanical approaches are:
  2.1- Remove weeds from inside and outside the greenhouse.
  2.1- Remove any leaves that have been infected.
  2.2- Complete closure of the greenhouse.
  2.3-Infected seedlings should be removed and disposed of.
  2.4- Crush aphids and blast them off with a jet of water.
3- Biological control:
  3.1- The Aphidius parasitoid is the most well-known of these natural enemies, and it is widely utilized commercially (spray rate is 2 insects per meter square of land). This parasite's female lays her eggs in the aphid's body. They hatch into a larva within days inside the aphid's body, which feeds on the contents of the aphid's body. The procedure takes no more than 13 days.
  3.2- Natural predators are: assassin bugs, big-eyed bugs, damsel bugs, earwigs, ground beetles, hoverflies, lacewings, ladybugs, minute pirate bugs, parasitic wasps, praying mantids, robber flies, soldier beetles, spiders, and syrphid flies (MULVIHILL, 2021).
  3.3- Common native insects such as ladybugs (Coccinella septempunctata) and aphid lion (Chrysopa pallens).
4- Organic aphid control by spraying tomatoes with plant extracts such as neem oil, and pyrethrin (MULVIHILL, 2021).
5- According to some non-published scientific sources, spraying tomatoes with a sodium bicarbonate ($NaHCO_3$) solution can minimize aphids. It is recommended that a homogeneous solution of (10 to 15 mg L-1) be prepared and sprayed on plants once a week. It is a certified organic retreat.
6- Chemical control: spraying chemically with synthetic insecticide of a particular type is strongly suggested as the last option if the infection surpasses the economic injury level. To avoid the emergence of resistant strains, chemical insecticides should be sprayed differently from season to season.

The previous examples demonstrate the possibility of incorporating extension and agricultural economics concepts into the framework of integrated pest management for any pests that pose a threat to the agricultural crop. Before beginning pest control, extensive research is required to determine the economic levels of pests in charge. Powdery mildew disease symptoms (Figure 4) and Aphis gossypii infections on tomatoes (Figures 5 and 6) (STREY, 2022) are picked from the PLANTIX application, version code 3.6.7, 227-R PRO.

Figure 4: Powdery mildew

Figure 5: Aphids on leaves

Figure 6: Aphids on fruits

RECOMMENDATIONS AND CONCLUSIONS

It is extracted from this study the academic and scientific values in the employment of agricultural extension and agricultural economics concepts to determine the decision that needs to be made by the integrated pest management specialist. This requires the analysis of the ecosystem and the biological status of the plant, then monitoring the density level of the pest to determine the economic limit of the pest, and finally, determining the appropriate action to combat it.

The level of pest density exceeding the critical economic limit (economic injury level) is about the transition point from traditional integrated pest control measures that use low-cost methods (usually organic biological procedures) to chemical pest control. In terms of agricultural extension and rural development, it is considered an agricultural technique regardless of the agricultural procedure adopted by growers.

One of the most important recommendations that this study creates is to conduct research experiments to determine the economic levels of each pandemic pest on the targeted crop.

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LEAN MANAGEMENT MODELS APPLICATION AND SAFETY MANAGEMENT OF LOGISTICS FIRM IN NIGERIA

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Abstract: *Research Background: The need for lean concepts application in the safety management of logistics processes cannot be emphasized as it can help in enhancing the flow of information and expediting processes within the supply network for improved organizational outcomes.*
Purpose: The study investigated the application of lean management models to the safety management of logistics firms in Nigeria.
Methodology: The study population includes 215 employees of Manal Plant hire Ltd Nigeria. 138 employees were chosen using a purposive sampling method. A self-administered questionnaire was designed to collect the primary data from the respondents. The data collected were analyzed using the structural equation modeling (SEM) technique to test the hypotheses developed in the study.
Results: The study's findings suggest that Process and Equipment Management has a positive and significant effect on the operational efficiency and workplace safety of the studied firms; employee empowerment has a positive and significant effect on the operational efficiency; technological innovation has a positive and significant effect on the operational efficiency, and that continuous improvement has a positive and significant effect on the operational efficiency and workplace safety.
Novelty: It is, therefore, concluded that the adoption of Lean Management has a positive and significant effect on the safety management of logistics firms. The study recommends that manufacturing, logistics, and service industries should be committed to carrying out process mapping to eliminate non-value adding operations in production as well as logistics and ensure the effective and continuous flow of logistics operations.

Keywords: *Lean Management, Logistics Firm, Management, Operational Efficiency, Workplace Safety.*
(JEL Classification: M11, C38)

INTRODUCTION

Competitive advantage is critical to businesses in today's complex business environment, and there is a growing need for optimal solutions that help businesses establish a competitive edge. Lean Thinking is one of such optimal solutions. Because of the rising dynamism of both internal and external changes in the environment, businesses must continue to enhance their operations processes regularly. The multifaceted notion of lean management, which is rapidly being applied in domestic and international economic practices, requires consideration while looking for ways and strategies to optimize performance (Anna, 2017). Lean Management is often associated with the reduction of waste by "learning" the organisation of any needless tasks. The lean strategy has been applied all across the world, and it has completely altered the service and manufacturing industries. Lean management can help logistics companies improve their performance and outcomes while also lowering costs and increasing employee and customer satisfaction. Effective top-down communication is required to equip employees with clear objectives and consistent mission statements while implementing lean (Cuatrecasas, 2002). Instead of working alone, successful lean implementation necessitated cross-functional collaboration among all employees.

The application of Lean management concepts necessitates the consolidation as well as comprehensive management of components that are more beneficial to the company, such as generally recognized organizational assets – risk, as well as human capital (Charron, Harrington, Voehl & Wiggin, 2014). Internal and external logistic procedures are meant to preserve the right time, location, quality, and cost while supporting the constant flow of manufacturing materials and finishing the delivery to end consumers. Furthermore, all logistic operations in the business must be consistently enhanced, particularly in terms of eliminating excessive waste and operations that do not bring value. Nine logistic areas have been identified where typical Lean losses might arise. These include procurement/purchasing, logistics service and customer support, stock management,

delivery and communication, demand forecasting and planning, transportation, material packing, reverse logistics, and, storage among others (Sopadang, Wichaisri & Sekhari, 2014).

The application of Lean concepts in logistics processes management will help to enhance the flow of information that passes through them. In the field of logistics, applying Lean entails several actions to enhance and expedite processes within the supply network, as well as the capacity to function in a variety of, typically insecure, situations for managing the company (Anna, 2017). Maintaining a balance between the customer's needs and the firm's functionality, on the other hand, necessitates proper capacity planning on both operational and strategic levels, standardization of operations and the time required to implement them, and highly qualified, multi-tasking personnel who really can easily accommodate a variety of processes. The majority of the causes of issues in manufacturing processes are linked to the nature of the processes, working conditions, and organization, as well as health and safety. Employees get dissatisfied as a result of the lack of action done to address these issues, which causes them to become less engaged at work. On the other hand, it has an impact on product quality, overall productivity, and competitive position at the corporate level (Furman, 2019).

A well-designed workplace promotes a safer, more efficient, and more productive workplace. It improves employee morale by instilling pride in their job and ownership of their obligations, as well as increasing a firm's competitiveness and profitability in the industry. The creation of educated, empowered, and engaged employees with the information, skills, and opportunity to operate in the workplace 5S (Sort, Set in order, Sweep, Standardize, Sustain) to remove or minimize risks is a cornerstone to worker safety in LM operations (Brown & O'Rourke, 2007). Furthermore, such safety policies are essential for world-class competitiveness; businesses that do not take a strategic approach to corporate safety will be less successful in the future. The addition of "safety" to 5S recently elevated it to 6S.

Lean management, along with its principles, has been touted as a significant tool for improving company performance. It is now widely used in a wide range of nations and sectors (Bhamu & Sangwan, 2014). However, its effectiveness is undeniable, lean management was not without flaws, and its impacts on performance are still hotly debated. Work processes provide varying levels of risk based on the safety dangers inherent in each step necessary to complete the process. Work may be made safer by carefully developing processes to reduce hazards. Lean approaches, which aim to reduce waste and improve efficiency, frequently result in fewer process stages, materials utilisation, and motions required. As a result of these reductions, the safety risks connected with those extra stages or materials may be eliminated or reduced. Reduced work-related accidents and illnesses mean lower expenses for workers' compensation insurance, retraining, and employee turnover (Laura, Isabelina & Joel, 2011).

Studies on how the lean method impacts the operational efficiency of organizations that adopt it have proven equivocal. Several studies have looked into the relationship between LMS and efficiency, particularly in industrial enterprises. Extant surveys of the literature revealed unanimity in favour of the premise that lean manufacturing promotes manufacturing efficiency (Okpala, 2013). Wamalwa, Onkware, and Musiega (2014), on the other hand, discovered that the implementation of the lean culture did not affect manufacturing efficiency. Furthermore, studies have looked at the relationship between safety and lean management, and have discovered a correlation between lean management adoption and increased safety. According to Nahmens and Ikuma (2009), lean is not only a useful tool for improving processes and reducing waste but it is also linked to increased safety in the construction sector. The level of effectiveness in the lean program, according to Wong, Wong, and Ali (2009), was substantially connected with the usage of lean practices in ergonomics and safety. These findings suggest that lean initiatives may have a favorable impact on ergonomics and safety. However, according to Womack, Armstrong, and Liker (2009), lean adoption does not necessarily result in improved ergonomics and safety.

The study on Lean management and safety management has not been given adequate attention in Nigeria. Just a few studies have been conducted thus far e.g Amos, Adebola, Asikhia, and Abiodun (2018); Odeyinka, Oluwaseyi, and Akinyele (2018) and are basically carried out in manufacturing firms with no consideration for logistics firms. Additionally, the use of structural equation modeling for data analysis has not been adequately adopted. The study, therefore, arises from the need to study the application of lean management models to the safety management of the logistics sector in Nigeria adopting structural equation modeling (SEM) for data analysis, a study by Manal Plant Hire Ltd, Nigeria.

LITERATURE REVIEW

In the course of investigating the concept of lean management and its effect on safety management in a logistics firm, the study adopted the Resource-Based View (RBV) theory as the basic foundation for the study. Also, empirical studies in relation to the study were reviewed.

Resource-Based View Theory

The resource-based view (RBV) stresses a company's hard-to-copy features as sources of exceptional performance and growth (Barney, 1986; Hamel & Prahalad, 1996). Resources that are difficult to transfer or acquire, such as those that require a steep learning curve or a major transformation in the organization's environment and culture, are more likely to be unique to the firm and thus harder to imitate. The RBV has shown to be useful in defining the basis on which a company's resources and capabilities function as long-term competitive advantages. As a result, every type of competitive edge is founded on the basis of resources and skills. According to the RBV, the ownership and management of strategic assets determine whether or not a company will make more money and gain a competitive advantage over its competitors.

The RBV looks at the competitive environment in which enterprises operate, but it does so from the inside out, starting with the firm's internal environment. RBV is widely used as a replacement for Porter's five-force model as a result of

this. The RBV emphasizes the firm's internal resources and capabilities while developing a plan to achieve a long-term competitive edge in the market. Internal resources and capabilities impact firms' strategic decisions in the external business environment. Some firms' skills also allow them to bring significance to the consumer value chain, launch new products, and expand into new markets. When a firm prioritizes its capabilities in order to get a competitive edge, it will focus on value chain rearrangement. The RBV leverages the resources and capabilities that exist inside the firms to create a long-term comparative advantage (Madhani, 2010).

Umair, Sajjad, Abdul, Hakeem, and Muhammad (2021) assessed the effect of lean and supply chain management practices on business performance. The role of competitive advantage as a mediating factor in the LP, SCMP, and firm performance relationships was also investigated. Data were collected using a simple random sampling approach. The data were analyzed through structural equation modeling techniques. The findings of this research demonstrate that LP, SCMP, and company performance have a substantial positive connection. The research also found that when companies employ the SCMP and LP, they may improve their financial performance.

Lokpriya and Vivek (2020) assessed how Lean and Green techniques and tools are being applied to enhance economic, social, and environmental performance, all of which have a direct impact on the overall performance of a business. The findings suggest that there is a significant connection between Lean and Green and that many Lean methods and technologies may help to enhance environmental sustainability, enabling academics and practitioners to benefit from their synergistic impacts in the manufacturing business.

The goal of Thunyachai, Lonkaniand, and Theeranuphattana (2020) are to learn more about the causal link between lean practices and business performance, with a competitive advantage as a moderating factor. A survey was conducted to determine the influence of six lean techniques, namely manufacturing planning and control, process and equipment, product design, human resource practices, customer relationship, and supplier relations on a company's performance, which includes financial and non-financial indices. The report includes 238 observations from Thai businesses. Ordinary least squares are used to estimate the parameters (OLS). The findings of this study show that lean techniques and non-financial performance have a negative connection. Despite this, there seems to be a strong link between competitive edge and the adoption of lean methods in businesses.

Sven-Vegard, Marco, Jan, and Fabio (2020) based their findings on a cross-sectional study of manufacturing businesses. The study deployed hierarchical multiple regression analysis to examine the connections between the adoption of lean production, factory digitalization, and operational performance. The findings demonstrate that both lean production and factory digitization independently contribute to better operational efficiency while concurrently controlling for the impacts of production repetitiveness, business size, and length of lean manufacturing deployment. Furthermore, they have a complementary (or synergistic) impact when used together that is higher than the sum of their separate benefits. These findings demonstrate that lean production is not outdated, but rather more necessary than ever in capturing the advantages of innovative technologies and transforming them into improved operational performance, particularly in light of the fourth industrial revolution on the horizon.

Prasanta, Chrisovalantis, Debashree, Soumyadeb, and Fouad (2020) examined the influence of LMP, SOI, and CSR (environmental and social) activities on sustainability and economic performance using hypothesis testing and structural equation modeling. The research is based on data from 119 SMEs in the manufacturing industry in the Midlands of the United Kingdom. The findings show that LMP and SOI make it easier to achieve both sustainability and economic performance and that SOI helps LMP achieve sustainability. Furthermore, whereas CSR activities moderate LMP to attain sustainable performance, they only marginally mediate SOI.

Tarurhor and Emudainohwo (2020) investigated the impact of lean manufacturing methods on a firm's performance, including lean culture as a moderating variable in the palm oil industries of Delta state. Palm oil industries, which have been in operation for over 10 years in Delta state, were used as the study's sample. The hypothesis was tested using data from a survey of 433 people. The quantitative data obtained with the aid of a questionnaire were analyzed using the structural equation model in the study. The study discovered that lean manufacturing, as measured by empowerment, training, and development has a favorable and significant impact on a company's product quality performance. The findings revealed that lean culture has a detrimental influence on a company's success. To avoid detrimental effects on the firm's performance, managers should consider the employees' cultural backgrounds as well as the location of the company.

Rodrigues, Alves, and Silva (2020) examined the extent of adopting lean and green practices in a group of firms, as well as the link between lean and green efforts in an industrial setting. The proposed model for the study contributes to the fields of logistics, sustainability, lean, and green in a conceptual way. A statistical method was utilized to build a Structural Equation Modelling (SEM) for lean and green practices to examine the potential of combining lean and green efforts. The findings revealed that the degree of lean and green practice adoption in Portuguese businesses is not effectively addressed or institutionalized. The statistical study also revealed a link between lean environmental practices and green activities. According to the findings, lean and green have a favorable influence on business logistics procedures.

Mohamad (2020) assessed the influence of factors such as lean manufacturing, supply chain relationship, and supplier performance on supply chain performance in Jordanian supply chain businesses. A nonprobability purposive sampling approach was used to obtain 293 answers from Jordanian supply chain experts. In this study, the PLS-SEM was employed. Version 3.2.8 of the SmartPLS software was utilized. Findings reveal that lean manufacturing has a substantial impact on supply chain relationships and supplier performance; however, while SC relationship has a significant impact on supplier performance, it has an insignificant impact on SC performance. Finally, SC performance is influenced by supplier performance.

Iranmanesh, Zailani, Hyun, Ali, and Kim (2019) considered lean culture as a moderator when examining the influence of lean manufacturing methods on a company's environmental performance. The data was collected via a survey of 187 Malaysian manufacturing companies, analysed using the partial least squares method. Process and equipment, customer interactions, supplier connections, and product design all seem to have a positive and substantial influence on long-term performance, according to the findings. It's also worth noting that the impact of process and equipment, as well as supplier relationships on long-term performance, were positively moderated by lean culture. These findings have significant implications for improving manufacturing businesses' long-term performance using lean manufacturing techniques.

Kevin, Imam, and Basuki (2019) investigated the function of management control systems (MCS) in assisting the adoption of lean management strategies to gain a competitive edge and enhance business performance. A questionnaire survey was used to obtain the data. This research included a total of 123 manufacturing executives. Structural equation models were used to go through the data. The findings demonstrate that a lean management approach is connected to MCS and competitive advantage positively and substantially; MCS has a favourable and substantial influence on the competitive edge and firm performance. These findings also suggest that MCS is a mediating variable in the interaction between lean management, competitive edge, and firm performance. The study's findings demonstrate the importance of lean MCS as a component of lean management in achieving a competitive edge and improving firm performance. This is the first proof that MCS mediates the link between the lean management approach, competitive edge, and firm performance.

Ofori-Nyarko, Boison, Asiedu, Agyapong, and Anamoo (2019) appraised the impact of lean operations on company performance while controlling for various business factors. A correlational approach was used, and 162 respondents were chosen from a selected study population of Accra-based beverage manufacturing companies. Hypotheses were tested using correlation tests and structural equation modeling. It was revealed that lean operations improved operational and financial success, but not marketing performance. Firm performance was not affected by any of the controlled variables or firm characteristics (company size, operational capital, firm age, total, and asset). According to the findings, as lean management becomes the more prevalent, the financial and operational performance of firms increases.

Research hypotheses and conceptual model

From the empirical review, the study developed and tested the following hypotheses:

H1 Process and equipment management has a significant effect on operational efficiency and workplace safety in Manal Plant hire Ltd Nigeria

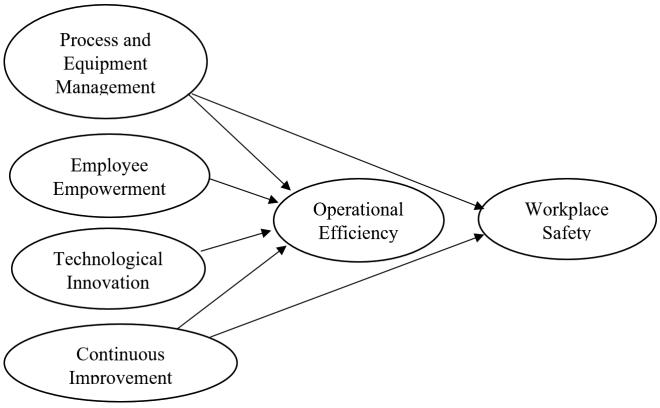
H2 Employee empowerment has a significant effect on operational efficiency in Manal Plant hire Ltd Nigeria.

H3 Technological innovation has a significant effect on operational efficiency in Manal Plant hire Ltd Nigeria.

H4 Continuous improvement has a significant effect on operational efficiency and work place safety in Manal Plant hire Ltd Nigeria.

Based on the hypotheses formulated, and the method of data analysis deployed (structural equation modeling) a research conceptual framework is developed:

Figure 1: A conceptual model of the application of the lean management model on safety management in a logistics firm



METHODOLOGY

The study used a descriptive survey research design to investigate the application of lean management models to the safety management of a logistics firm in Nigeria. The study purposively selected Manal Plant hire Ltd among other logistics firms Ogun State as the study firm, in which its employees make up the target population of the study. The number of employees of the study's firm is two hundred and fifteen (215). The purposive sampling technique was adopted to pick the more reliable participants from the target population. The respondents were selected across the various department of the study firm, which includes: Logistics, Heavy lift, Administrative, and Safety departments. Considering the level of precision, level of confidence, and degree of variability in attributes being measured, the sample size was determined using Krejcie and Morgan's (1970) formula since the population is finite and known. The mathematical calculation is given below:

$$S = x2\ NP(1-P)/(d2(N-1) + X2\ P(1-P)) \quad \text{---------- (1)}$$

S = required sample size
X^2 = table value for chi-square for 1 degree of freedom at the desired confidence level of 95% (3.841)
N = the population size
P = estimate proportion of attributes in the population (assumed to be 50% i.e. 0.50 to provide the maximum number of sample size)
d = degree of accuracy or error margin expressed as a proportion +/- 5% (0.05)

Mathematically,

$$S = ((3.841)(215)(0.5)(1-0.5)) / ((0.05)2(215-1) + (3.841)(0.5)(1-0.5))$$
$$S = 206.4 / (0.535 + 0.96025) = 206.45 / 1.49525 = 138.037$$

S = 138 respondents (approx.)

The study utilized primary data, generated with the aid of primary tool (questionnaire) with closed-ended questions, structured based on the research objectives. The questionnaire was chosen to allow for the systematic gathering of data and facilitates data analysis for business decision. The questionnaire was segmented into sections, such as section A, B, C, D, E, and F. Section A captures the respondents' profiles, section B covers statements related to process and equipment management, adapted from the study of Mohammad et al. (2019); section C presents the statements on employee empowerment in line with Lida, Iravan, Kamran, and Pouran (2019).; section D presents the statements on technological innovation, adapted from the study of Alfred, Reuben, and James (2018); section E covers the statements on continuous improvement; section F presents statements on safety measures, coined by the researcher. The items in section B to G were structured based on a five-point Likert scale: Strongly Disagree (SD), Disagree (D), Undecided (U), Agree (A), and Strongly Agree (SA).

Descriptive statistical analysis was used to achieve the frequency distribution, and percentage, of respondents'' profiles with the aid of a statistical package for social sciences, (SPSS) version 26. Covariance-Based Structural Equation Modelling was deployed with the aid of AMOS Graphics for modeling and analyzing the effect of latent exogenous constructs (human resource planning, information technology, and quality planning) on latent endogenous constructs (productivity and financial performance) As such, the hypotheses developed were tested using the Covariance-based Structural Equation Modelling method and thus, achieve the objectives of the study. CB-SEM method estimates interrelated dependence in a single analysis and produces data in a visual display that is easy to interpret. It also can combine both measurement models and structural models and it is more reliable when assessing the strength of the relationship between two or more latent constructs.

The reliability and validity of the measuring items were assessed using confirmatory factor analysis. The internal correctness and consistency of the research instrument were assessed using composite reliability and Cronbach's Alpha test. The construct validity of the measurement items was investigated, as well as the convergent and discriminant validity of the measurement model.

ANALYSIS

This section discusses the study of respondents' profiles, confirmatory factor analysis for assessing reliability and validity, and structural equation modeling for testing hypotheses.

Table 1: Respondents' Profiles

Responses	Frequency	Percent (%)
Gender		
Male	96	72.7
Female	36	27.3
Total	**132**	**100.0**
Age		
22-31years	43	32.6
32-41 years	47	35.6
42-51years	26	19.7
52years and above	16	12.1
Total	**132**	**100.0**
Qualification		
ND/Equivalent	28	21.2
HND/B.Sc	80	60.6
MBA/M.Sc	24	18.2
Total	**132**	**100.0**
Length of Service		
0-5yrs	45	34.1
6-10yrs	64	48.5
11yrs and above	23	17.4
Total	**132**	**100.0**
Position		
Executive Management	8	6.1
Senior Staff	75	56.8
Junior Staff	49	37.1
Total	**132**	**100.0**
Department		
Logistics	35	26.5
Heavy lift	50	37.9
Administrative/ Safety	47	35.6
Total	**132**	**100.0**

Source: Field Survey, 2021

Confirmatory Factor Analysis

The study employed a pooled Confirmatory Factor Analysis (CFA) to analyse the validity and reliability of the measurement items so as to determine the appropriateness of the measurement model. Below are the factor loadings of the items extracted from the first-order confirmatory factor analysis (CFA).

Table 2: Measurement model evaluation

Constructs	Items	Factor Loadings	Significance
Process and Equipment Management	There is an effective and continuous flow of operations in my firm	0.814	0.000
	Operating machines are readily available and maintain to mitigate risk associated with operations.	0.926	0.000
	The operation process is effectively managed for workplace safety.	0.926	0.000
	Process mapping is carried out in my firm to eliminate non-value adding operations.	0.804	0.000
	Order and cleanliness in operations are implemented in my firm	0.730	0.000
Employee Empowerment	My firm engages in human capital development and creates a safe workplace environment.	0.914	0.000
	My firm engages its employees in continuous improvement efforts in logistics service to minimize the risk associated with logistics.	0.872	0.000
	There are multifunctional (multi-skill) employees in my firm.	0.820	0.000
Technological Innovation	My firm adopts system automation in logistics operations to guarantee workplace safety.	0.954	0.000
	My firm easily adapt to new technology	0.902	0.000
	My firm is highly innovative in managing risk associated with logistics and ensuring workplace safety	0.732	0.000
	My firm continuously improves its production/operation process for effective performance	0.835	0.000
Continuous Improvement	We constantly improve our mode of operation to guarantee workplace safety.	0.869	0.000
	The logistics operations are effectively managed in my firm.	0.751	0.000
	Safety performance evaluation and measurement are effective done in my firm	0.914	0.000
	My firm focused on system improvement to identify core problems and constraints in logistics operations.	0.687	0.000
	Lean practices adopted have improved the work safety in my firm	0.771	0.000
Workplace Safety	The rate of job satisfaction is high in my firm	0.813	0.000
	Our logistics operations have greatly improved.	0.806	0.000
Operational Efficiency	My firm's productivity rate has improved through lean management.	0.981	0.000
	The cost of operation is minimized through the application of lean management.	0.848	0.000

Table 2 shows that the factor loading of each item is > 0.50 and significant, which implies that the factor loadings can be used to assess the reliability and validity of the research instrument.

Table 3: The fitness of the CFA Model

Goodness of fit Statistic	Model Values	Satisfactory values Model fitness
$\chi 2$ /df	2.454	< 3.00
P-value	0.000	< 0.05
IFI	0.931	> 0.9
TLI	0.908	> 0.9
CFI	0.948	> 0.90
RMSEA	0.066	< 0.08

The CFA model shows a good fit as the revealed that the structural indices such as Incremental Fit Index (IFI), Comparative Fit Index (CFI), Tucker-Lewis coefficient (TLI), and Root Mean Square Error of Approximation (RMSEA) show that the CFA model for the latent constructs satisfies the required level of model fit. Since the indices for attaining the fitness of the CFA model have corresponding values that are larger than the suggested values, they are a perfect fit. The CFA model is seen to be a good fit.

Table 4: Reliability and Validity of the Constructs

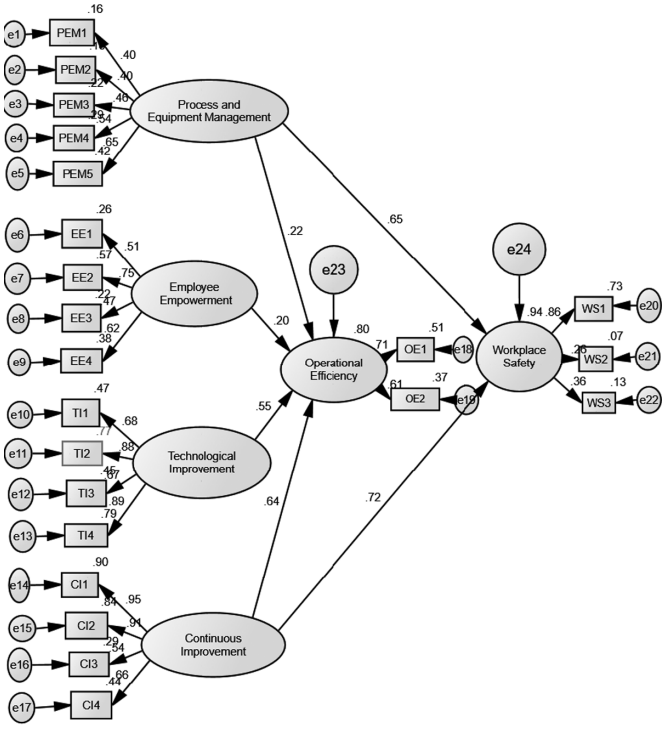
Constructs	CR	Cronbach's Alpha	AVE	PEM	EE	TI	CI	WS	OE
Process and Equipment Management	0.974	0.925	0.711	**0.843**					
Employee Empowerment	0.903	0.944	0.786	0.239	**0.886**				
Technological Innovation	0.901	0.922	0.739	0.275	0.420	**0.860**			
Continuous Improvement	0.890	0.883	0.657	0.661	0.076	0.077	**0.810**		
Workplace Safety	0.839	0.838	0.635	0.576	0.160	0.142	0.611	**0.797**	
Operational Efficiency	0.913	0.944	0.841	0.511	0.239	0.230	0.808	0.743	**0.917**

Note: The Off-diagonal values are correlations between constructs, while the diagonal values (in bold) are the square root of AVE between the latent constructs.

The average variance extracted (AVE), Cronbach's alpha and composite reliability (CR) were computed to assess the convergent validity and reliability of the research instrument. The convergent validity was substantiated by computing the AVE for each of the latent constructs and the threshold for convergent validity is that the value of the AVE of the latent constructs should be ≥ 0.5 (Sobh, 2010). Furthermore, the reliability of the research instrument was tested to assess its internal accuracy and consistency by adopting composite reliability and Cronbach's alpha test. The reliability test was also done to assess the shared variance among the latent constructs. According to Hair, Hult, Ringle, and Sarstedt (2016) the benchmark for Cronbach's alpha and CR is that the value of Cronbach's alpha and composite reliability of a latent construct should be ≥ 0.7 for the study. As shown in Table 4, Cronbach's alpha and composite reliability of the constructs is > 0.7; the average variance extracted (AVE) of the constructs is > 0.5, thereby confirming the internal accuracy and convergent validity of the constructs.

The discriminant validity of the constructs was assessed based on the hypotheses developed in the study. When operationalized, discriminant validity explains the level of relationship or divergence between two variables that should not be theoretically comparable, i.e. the amount to which a construct is separate from others and does not measure the same thing. It is a must to recognize and comprehend the significance of a variable. Table 4 shows the relationship among the constructs with the square root of the AVE on the diagonal. The values of the square root of AVE, i.e., the diagonal values (in bold) for each of the constructs, are more than the inter-correlation values of the constructs, indicating that the constructs met the benchmark of discriminant validity (Lin & Chen, 2008). Furthermore, the results show that there is a weak to moderate positive relationship within the constructs. The correlation coefficient within the variables is between r = 0.011 and 0.787, all were below 90%, validating the nonexistence of any common method bias. Since the results of the correlation test are less than the threshold of r < 0.9 according to Pallant (2010) it implies that there were no multi-collinearity problems among the variables.

Figure 2: Structural Model for the Application of Lean Management Models to Safety Management



Test of Hypotheses

The study adopted CB-SEM for test of hypotheses, which is a path analytical model to ascertain the causal effect of the latent exogenous variables on the latent endogenous variables in the study.

Figure 2 displays the path diagram resulting from the structural modeling analysis. The path analysis assessed the degree of the association between the exogenous variables and the endogenous variables in the model. The arrows between the constructs in the path analysis depict the alternate hypothesis, it implies that the independent constructs (process and equipment management, employee empowerment, technological innovation, and continuous improvement) are expressed in alternate hypotheses to have a significant effect on the dependent constructs (operational efficiency and workplace safety). The model's explanatory power is assessed by two values: R^2 (squared multiple correlations or regression) and path coefficient. The path coefficients demonstrate the effect of the independent construct on the dependent construct. The R^2 shows the proportion of variance a dependent construct represents in the model. As shown in the path analysis, the R^2 value for operational efficiency is 0.80. This implies that the predictors (process and equipment management, employee empowerment, technological innovation, and continuous improvement) of Lean Management, taken as a set explained 80.0% variation in operational efficiency. The R^2 value for workplace safety is 0.94. This implies that the predictors (process and equipment management, and continuous improvement) explained a 94.0% variation in workplace safety.

Table 5: The fitness of the Structural Model

Goodness of fit Statistic	**Structural Model Values**	**Recommended* values for good fit**
$\chi 2$ /df	2.72	< 3.00
P-value	0.000	< 0.05
NFI	0.926	> 0.9
IFI	0.946	> 0.9
CFI	0.935	> 0.90
RMSEA	0.057	< 0.08

From the test result of the SEM model in table 6, it is observed that the structural indices adopted such as Incremental Fit Index (IFI), Normed Fit Index (NFI), Comparative Fit Index (CFI) and Root Mean Square Error of Approximation (RMSEA) show that the SEM model for the constructs satisfies the threshold of model fit. The structural model is judged to have a good fit since the indices for obtaining the goodness of fit of the structural model demonstrate an acceptable fit with their corresponding values larger than the required values.

Table 6: Direct effect of lean management models on safety management

Links in the model	Hypotheses	Path Coefficient	Critical Ratio (CA)	p-value	Result
PEM→OE	H_{1a}	0.22	2.288	0.022	Accepted
PEM→WS	H_{1b}	0.65	5.721	0.000	Accepted
EE→OE	H_2	0.20	2.086	0.037	Accepted
TI→OE	H_3	0.55	6.119	0.000	Accepted
CI→WS	H_{4a}	0.64	5.979	0.000	Accepted
CI→OE	H_{4b}	0.72	7.654	0.000	Accepted

Table 6 shows the direct effect of lean Management models (process and equipment management, employee empowerment, technological innovation, and continuous improvement) on safety management proxied by operational efficiency and workplace safety. Based on the results of the path analysis, the path coefficient of process and equipment management to operational efficiency is 0.22, which implies that a unit increase in process and equipment management explained a 22.0% variation in operational efficiency. The path coefficient of process and equipment management to workplace safety is 0.65, it implies that a unit increase in process and equipment management explained 65.0% variation in workplace safety. The path coefficient of employee empowerment to operational efficiency is 0.20, it implies that a unit increase in employee empowerment explained a 20.0% variation in operational efficiency. The path coefficient of technological innovation to operational efficiency is 0.55, it implies that a unit increase in technological innovation explained a 55.0% variation in operational efficiency. The path coefficient of continuous improvement to operational efficiency is 0.64, it implies that a unit increase in continuous improvement explained 64.0% variation in operational efficiency. The path coefficient of continuous improvement to workplace safety is 0.72, it implies that a unit increase in continuous improvement explained a 72.0% variation in workplace safety.

Furthermore, the critical ratio (CR) for all hypotheses is greater than 1.96. p-vale < 0.05, which implies that the direct effect of all the latent dependent constructs on the dependent constructs is significant.

In summary, H_{1a} is accepted, thereby, accepting the alternate hypothesis and concluding that process and equipment management has no positive and significant effect on operational efficiency. H_{1b} is accepted, thereby, rejecting the null hypothesis and concluding that process and equipment management has a positive and significant effect on workplace safety. H_2 is accepted, thereby, rejecting the null hypothesis and concluding that employee empowerment has a positive and significant effect on operational efficiency. H_3 is accepted, thereby, rejecting the null hypothesis and concluding that technological innovation has a positive and significant effect on operational efficiency. H_{4a} is accepted, thereby, rejecting the null hypothesis and concluding that continuous improvement has a positive and significant effect on operational efficiency; H_{4b} is accepted, thereby, rejecting the null hypothesis and concluding that continuous improvement has a positive and significant effect on workplace safety.

Table 7: Results Summary

NO	Critical Ratio (CA)	Path Description	Study's findings
H_{1a}	Process and Equipment Management→ Operational Efficiency	FWS→EP	Accepted
H_{1b}	Process and Equipment Management→ Workplace Safety	FWS→OE	Accepted
H_{2a}	Employee Empowerment→ Operational Efficiency	JA→EP	Accepted
H_{2b}	Technological Innovation→ Operational Efficiency	JA→OE	Accepted
H_{3a}	Continuous Improvement→ Operational Efficiency	SS→EP	Accepted
H_{3b}	Continuous Improvement→ Workplace Safety	SS→OE	Accepted

DISCUSSION AND CONCLUSION

The findings reveal that Process and Equipment Management has a positive and significant effect on the operational efficiency and workplace safety of the studied firms. This depicts that the surveyed firm carries out process mapping to eliminate non-value-adding logistics operations and ensures an effective and continuous flow of logistics operations. This enhances the operational efficacy of logistics firms and guarantees the safety of the employees in the process. These findings are consistent with Iranmanesh et al. (2019) revealing that process and equipment, customer interactions, supplier connections, and product design all appear to have a positive and substantial impact on long-term performance, according to the findings. It's also worth noting that the impacts of process and equipment, as well as supplier relationships, on long-term performance were positively moderated by lean culture. In contrast, Thunyachai et al. (2020) in their findings revealed that lean techniques (manufacturing planning/control, product design, process and equipment, human resource practices, customer relationship, and supplier relations) have a negative connection with non-financial performance. However, there seems to be a strong link between competitive advantage and the adoption of lean methods in businesses. According to Bergmiller (2006), over-processing and the resulting machinery use wastes energy and resources while also increasing emissions production. Over-processing results in the produc-

tion of toxic compounds and pollutants, as well as increased water use and energy waste. The findings show that employee empowerment has a positive effect on the operational efficiency of the studied firm. The result reflects that the employees are productively engaged in continuous improvement efforts in logistics service to improve logistics performance and minimize the risk associated with logistics. This result is consistent with those of Bhasin (2012); Fullerton Kennedy, and Widener (2013). Employee empowerment, according to Maskell, Kariuku, and Kiambati (2012), helps the application of lean management practices as a social control mechanism. It was also discovered that successful empowerment equips workers with the information and competence they need to make sound decisions and take action to accomplish the key success characteristics of lean management. Keitany and Riwo-Abudho (2014) revealed that changing management style and incorporating all employees at all levels, as well as improved inventory management, results in a more effective lean manufacturing process. Human resources practices, according to Iranmanesh et al. (2019), played a critical part in lean manufacturing by fostering a positive working environment and fostering human capital development. It will be difficult to find a company that can fulfill its objectives without human resources. Human resources have a major role in a firm's ability to execute lean manufacturing, produce high-quality goods, and gain a competitive edge over competitors.

Furthermore, the findings reveal that technological innovation has a positive effect on the operational efficiency of the firms understudied. The study shows that system automation adopted in logistics operations guarantees workplace safety. It is also indicated that the surveyed firm is highly innovative in managing risk associated with logistics to facilitate efficient operation in logistics. This result supports the findings of Lida, Iravan, Kamran, and Pouran (2019), who found that technology has the biggest influence on the pattern of lean management in public hospitals to enhance service quality. Ker, Wang, Hajli, Song, and Ker (2014) examined the role of lean technology in improving hospital service quality and reducing waste and found that using digital scanning technology reduced time procedures significantly. Sven-Vegard et al. (2020) show that lean production is not outdated, but rather more important than ever in capturing the advantages of new technologies and converting them into enhanced operational performance, particularly in light of the fourth industrial revolution on the horizon.

Finally, the findings reveal that continuous improvement has a positive and significant effect on operational efficiency and workplace safety in the studied firms. The results show that the firm has focused on system improvement to identify core problems and constraints in logistics operations. Safety performance evaluation and measurement are effectively carried out to constantly improve the mode of operation and guarantee workplace safety. These findings are consistent with previous research. According to Openda (2013), the majority of Kenyan businesses feel that lean manufacturing approaches, such as continuous improvement, promote long-term performance and success. Less process waste, decreased inventory, shorter lead times, lower rework costs, and improved process knowledge was identified as benefits of using lean manufacturing principles in the research. According to Gableta, Cierniak-Emerych, and Dziuba (2016), a firm that decides to use the 6S (sort, set in order, shine, standardize, sustain, and safety) method of lean must adopt a preventative strategy defined by the discovery of all dangers that may in the future become the root cause of an accident, for which improvement activities should be offered in line with the specific phases of 5S. This method will enable the establishment of a secure workplace.

Lean management, along with its principles, has been touted as a significant tool for improving company performance and safety management. It is now widely used in a wide range of sectors. Generally, as the application of Lean Management becomes more prevalent, company performance in terms of operational and financial performance increases. The study draws specific conclusions: The LM practices adopted by Logistics firms have a positive and significant effect on operational efficiency and workplace safety, as they optimize the logistics operations and guarantee the safety of the employees in the process. In view of this, Logistics firms should put in place a focused system improvement to identify the core problem and constraints in logistics operations, and that safety performance evaluation and measurement should be carried out effectively to constantly improve the mode of operation and guarantee workplace safety.

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MANAGEMENT ISSUES OF CROPPING WITH SORGHUM IN THE PRODUCTION STRUCTURE – A CASE STUDY OF HUNGARY

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Abstract: *One of the goals of the developments is to improve the efficiency of the activity by making the currently used traditional production structure more flexible and by making the necessary changes to the technology in the case of farmers with large agricultural land, having necessary machinery and equipments required. Farms with larger arables land are able to offset the effects of changes affecting efficacy and profitability. The main sector of Hungarian agriculture is crop production, so performance is largely determined by the annual output of the crop production sector and the price development of crop products. In the course of our analytical work, we defined a farm of 2100 hectares, for which we examined crop production, crop machinery and economic aspects. From the enterprise data, farm level results compiled according to the crop structure were calculated. Sorghum is suitable for replacing corn in the crop rotation in areas with unfavorable conditions, so a stably growing crop can be added to the crop rotation of autumn ears of corn, rape, and sunflower, instead of corn. It does not hinder the machinery modernization efforts either, since the precision tools and developments already started in corn production can be used well, and it does not require a special equipment park. At the same time, in light of the increasingly frequent negative climatic effects, sorghum's integration into the plant production structure is encouraging, because we have to count on 3-4 drought years in a decade. Based on our analysis, the inclusion of sorghum in the crop structure does not significantly reduce the available income, which is acceptable in the given economic environment. However, its stability can significantly contribute to improving the resilience of farming, especially in comparison with corn.*

Keywords: *crop production structure, sorghum, machinery, operations, cost, profit*
(JEL Code: Q12)

INTRODUCTION

One of the goals of the developments is to improve the efficiency of the activity by making the currently used traditional production structure more flexible and by making the necessary changes to the technology in the case of farmers with large agricultural land with the help of the acquired tools. Efforts to improve the efficiency of farming must be present as a constant demand (SZŰCS-FARKASNÉ FEKETE, 2008), but only taking into account the environmental effects as it was highlighted by KOVÁCS (2011) discussing agri-product evaluation and biodiversity measurement as a tool to reveal effects. In order to complete all tasks in an optimal time, it is necessary to assess the available power and machine capacity, as well as to plan the extra machine capacities essential for the implementation of the technology. SMUK et al. (2009) established that there is a close correlation between the return on investment for the introduction of precision farming as a modern approach and asset structure and the plant sizes. In addition to the assumed five- and six-year payback, plants with larger areas are able to offset the change in yield or the expected interest level. KALMÁR et al. In his article published in 2004, he states in relation to precision

plant protection technology that the technology can actually only be an alternative for farms larger than 1000 ha. KEMÉNY et al. (2017) their investigations also covered farms cultivating areas larger than 1,000 hectares and smaller, emphasizing that we can expect returns for those cultivating smaller areas as well. This is of particular importance in our country, since the main sector of Hungarian agriculture is crop production, so performance is largely determined by the annual output of the crop production sector and the price development of crop products (POPP et al., 2018). This is also why it is important to change our production structure by adapting to the framework given by the natural-economic environmental factors. This belongs to the flexibility of company operations, which is an increasingly significant expectation in the agri-food sector as well (YOUSUF et al. 2022). A more flexible operation should be a constant aspiration for the productivity of the plant growing sectors and to increase their competitiveness (FELFÖLDI, 2013).

The place of grain sorghum in the crop structure is ensured by its beneficial properties. It is an excellent drought and stress tolerant plant. One of the advantages of sorghum is that it can be grown successfully in areas with poor conditions, prone to drought and stress, where traditionally produced field crops are no longer AGROSZEMEK (2019). Crops that can be grown successfully in regions where other crops cannot be grown economically are particularly important for rural development, as they contribute to maintaining the rural population and increasing income-generating capacity (BORSOS-BITTNER, 2004; BITTNER et al, 2009). It has outstanding stability even on average and poor growing sites, and its productivity in intensive conditions can be up to 12 t/ha. It is characterized by very good adaptability. Its yield stability is outstanding even in dry conditions (KITE, 2021). Support for logistics is indispensable, and a basic condition for the technology is the available transport capacity of the right size. The number of hours suitable for work on each day is important knowledge, but the possibility of the frequency of technical problems and the time intervals for their elimination must also be taken into account (HUSTI, 2007). In the case of companies engaged in crop cultivation, the problem exists in many cases of having to transport large quantities of crops over long distances, which requires the setting up of significant additional capacities (HUSTI 2007). To determine the appropriate number of power and work machines, we calculate the ratio of theoretical and actual area performance. The improvement of the actual field performance can be achieved by organizing several shiHUFs, by cultivating under optimal conditions or even by blocking (HUZSVAI et al, 2012). If we do not carry out plant cultivation technology interventions at the right time, we may have loss of yield and income.

MATERIALS AND METHODS

In the course of our analytical work, we defined a farm of 2100 hectares, for which we examined crop production, crop machinery and economic aspects. We based our data on cultivation technology and enterprise management data for the years 2019-2021, in order to evaluate the profitability and efficiency of production by a complex economic analysis of its technological process (APÁTI et al. 2010; SULYOK et al. 2013). Efficiency can be measured in different ways, with different levels of indicators (NÁBRÁDI et al., 2008). During We determined the cropping structure consisting of maize (16.5%), sorghum (16.5%) and winter cereals (33%) that play a decisive role in the sowing structure, as well as the oil crops such as rape (16.5%) and sunflower (16.5%). The machinery system necessary to ensure proper cultivation was put together and assigned to the technological operations of each crop enterprise.

Taking all of this into account, we determined the machinery work costs required for the implementation of the entire plant cultivation technology in the case of the developed technologies. These cost calculations covered both the specific operational costs and the logistics activities that serve them. The material costs were adjusted to the level necessary for the agreed high production level, in addition, direct personnel costs (e.g. plant protection engineering services) and other costs (e.g. nutrient supply consulting services) were accounted for. Knowing the material costs, machine work costs, labor costs and other direct costs, the sectoral cost-income analysis was carried out for all plant and cultivation technology variants. From the enterprise data, farm level results compiled according to the crop structure were calculated (KAY et al.1994).

RESULTS AND DISCUSSION

The costs of machinery work in field crop production technologies

Successful cultivation is influenced by the quality of the pre-crop. Winter wheat is sown after a pre-crop of rape or sunflower. If sown after rape, then stubble stripping is done in July and chemical stubble care in August. Soil cultivation with no ploughing takes place in the second half of August. In September, basic fertilizers are spread, and seed bed formation and sowing are excuted. In the case of varietal wheat, sowing is postponed to October. Sowing is followed by an autumn weeding operation. Top fertilization takes place in March and April. Plant protection works are carried out in April-May. In July, the work operations of harvesting and collecting grains are carried out (Table 1). The cost of machinery work for the entire cultivation technology of winter wheat is HUF 101,564/ha, of which the cost of logistics is HUF 28,961/ha (28%).

Table 1: Cost of machinery work for the winter wheat enterprise (HUF/ha)

winter wheat				
month	**operation**	**machinery cost of operation**	**logistics cost of operation**	**cost of machinery work**
july	stubble stripping	9 285	0	9 285
august	chemical stubble care	1 634	1 135	2 769
august	soil cultivation with no ploughing	10 941	0	10 941
september	fertilization	1 257	2 972	4 229
september	seed bed formation	9 562	0	9 562
september	sowing	9 498	2 035	11 533

october	spraying	1 634	1 135	2 769
march	top fertilization	1 634	1 135	2 769
april	top fertilization	1 634	1 135	2 769
april	spraying	1 634	1 135	2 769
may	spraying	1 634	1 135	2 769
july	harvesting	22 256	0	22 256
july	collecting grains	0	17 144	17 144
total		**72 603**	**28 961**	**101 564**

Source: Author's own construction

The rape is entered into the sowing structure following the winter wheat harvested. In July, stubble stripping takes place, then in August, chemical stubble care, fertilization, stripped cultivation are carried out. Sowing takes place at the beginning of September, followed by two plant protection interventions. In October, a new plant protection is carried out, followed by inter-row cultivation. Top fertilization and plant protection are carried out in March. In April, another row cultivation and plant protection work are executed. Plant protection intervention is required twice in May and once in June. Harvesting and collecting grains take place in June (Table 2). The cost of machinery work for the presented technology of rape is HUF 101,755/ha, of which the cost of logistics is HUF 31,430/ha (31%).

Table 2: Cost of machinery work for rape enterprise (HUF/ha)

rape				
month	**operation**	**machinery cost of operation**	**logistics cost of operation**	**cost of machinery work**
July	stubble stripping	9 285	0	9 285
August	chemical stubble care	1 634	1 135	2 769
August	fertilization	1 257	2 972	4 229
August	stripped cultivation	10 059	0	10 059
September	sowing	7 135	2 798	9 933
September	spraying	1 634	1 135	2 769
September	spraying	1 634	1 135	2 769
October	spraying	1 634	1 135	2 769
October	cultivating	7 321	1 621	8 942
March	top fertilization	1 257	2 972	4 229
March	spraying	1 634	1 135	2 769
April	cultivating	7 321	1 621	8 942
April	spraying	1 634	1 135	2 769
May	spraying	1 634	1 135	2 769
May	spraying	1 634	1 135	2 769
June	spraying	1 634	1 135	2 769
June	harvesting	11 984	0	11 984
June	collecting grains	0	9 231	9 231
Total		**70 325**	**31 430**	**101 755**

Source: Author's own construction

The pre-crop of the sunflower is corn. Stripped cultivation takes place at the end of October. Plant protection works are carried out in March. Sowing takes place in April, copleted by a plant protection intervention and inter-row cultivation with a nutrient cultivator. Plant protection work takes place twice in May, followed by the stock drying operation at the beginning of September. Harvesting and collecting grains takes place in September, and this is also when we have to perform the stem crushing operation (Table 3). The cost of the machinery work of the sunflower production technology is HUF 70,966/ha, of which logistics is represented by HUF 19,325/ha (27%).

Table 3: Cost of machinery work for sunflower enterprise (HUF/ha)

sunflower				
month	**operation**	**machinery cost of operation**	**logistics cost of operation**	**cost of machinery work**
October	stripped cultivation	10 059	0	10 059
March	spraying	1 634	1 135	2 769
April	sowing	7 135	2 798	9 933
April	spraying	1 634	1 135	2 769
April	cultivating	7 321	1 621	8 942
May	spraying	1 634	1 135	2 769
May	spraying	1 634	1 135	2 769
September	spraying	1 634	1 135	2 769
September	harvesting	11 984	0	11 984
September	collecting grains	0	9231	9 231
September	stem crushing	6 972	0	6 972
Total		**51 641**	**19 325**	**70 966**

Source: Author's own construction

In the case of corn produced by applying soil loosening technology, the pre-crop is winter wheat. In Stubble stripping in July and chemical stubble care, spreading of basic fertilizers, basic cultivation with soil loosening take place on the production area in August. In March, weed control activities adapted to the technology are carried out, followed by sowing, plant protection and a row cultivation operation in April. In May, the second inter-row cultivation and top fertilization operation takes place. In June, if necessary, a third top fertilization must be carried out in order to achieve higher yield. harvest. Harvesting, collecting grains and drying are carried out in October (Table 4). The cost of the machinery work of the corn production technology based on soil loosening is 159,478 HUF/ha, of which the cost of logistics is 39,495 HUF/ha (25%).

Table 4 . Cost of machinery work for corn enterprise (HUF/ha)

corn				
month	**operation**	**machinery cost of operation**	**logistics cost of operation**	**cost of machinery work**
July	stubble stripping	9 285	0	9 285
August	chemical stubble care	1 634	1 135	2 769
August	fertilization	1 257	2 972	4 229
August	soil loosening	10 458	0	10 458
March	spraying	1 634	1 135	2 769
April	sowing	7 135	2 798	9 933
April	spraying	1 634	1 135	2 769
April	cultivating	7 320	1 621	8 941
May	cultivating	7 320	1 621	8 941
June	top fertilization	2 066	703	2 769
October	harvesting	34 240	0	34 240
October	collecting grains	0	26 375	26 375
October	drying	36 000	0	36 000
Total		**119 983**	**39 495**	**159 478**

Source: Author's own construction

In the case of grain sorghum sown after corn, fertilization and plowing take place in October. In the spring, seed bed formation takes place, which is followed by sowing, plant protection operations and inter-row cultivation in April, supplemented with the first top fertilization in May. The second top fertilization and inter-row cultivation take place in one run, followed by the third top fertilization in June if necessary (Table 5). Harvesting, collecting grains and drying are the tasks of the month of October. The cost of machinery work for grain sorghum cultivation technology is HUF 129,726/ha, of which the cost of logistics is HUF 27,994/ha (22%).

Table 5 . Cost of machinery work for sorghum enterprise (HUF/ha)

sorghum				
month	**operation**	**machinery cost of operation**	**logistics cost of operation**	**cost of machinery work**
October	fertilization	1 257	2 972	4 229
October	ploughing	24 224	0	24 224
March	seed bed formation	9 562	0	9 562
April	sowing	7 135	2 798	9 933
April	spraying	1 634	1 135	2 769
April	cultivating	7 321	1 621	8 942
May	cultivating	7 321	1 621	8 942
June	top fertilization	2 066	703	2 769
October	harvesting	34 240	0	34 240
October	collecting grains	0	17 144	17 144
October	stem crushing	6 972	0	6 972
Total		**101 732**	**27 994**	**129 726**

Source: Author's own construction

In summary, the largest cost of machinery work is HUF 156,713/ha that is incurred in the course of corn production. The reason for this is drying, which is necessary in general, and corn gives a heavy bulky product to be harvested and moved. Sorghum has a slightly higher machine labor cost than the other three crops. In the case of winter cabbage and winter wheat, the machinery labor costs are roughly the same: winter wheat 101,567 HUF/ha, winter cabbage 104,527 HUF/ha. In the case of rapeseed, more plant protection interventions are needed, but the amount of the crop is less than in the case of wheat, which has transport and harvesting costs.

Enterprise costs and revenue

For the winter wheat, we established that the cost of input materials (fertilizer, plant protection agent and seed) per hectare is HUF 110,000 (50% of all direct costs), the cost of machinery work is HUF 101,567/ha (46%), personnel costs are HUF 5,000/ha (2%), other direct costs are HUF 5,000/ha (2%), (Table 6). With a yield of 6.5 t/ha and a sales price of 50,000 HUF/t typical for 2019, sales revenue is 325,000 HUF/ha, and the margin is 103,433 HUF/ha. The break-even yield is 4.9 t/ha, the cost of production is HUF 37 538/t.

Table 6: Cost and revenue for the winter wheat enterprise

winter wheat		
Cost of input materials (HUF/ha)	110 000	50%
Cost of machinery work (HUF/ha)	102 000	46%
Personnel cost (HUF/ha)	5 000	2%
Other cost (HUF/ha)	5 000	2%
Direct cost (HUF/ha)	222 000	100%
Total cost (HUF/ha)	244 000	
Yield (t/ha)	6.5	
Sales price (HUF/t)	50 000	
Sales revenue (HUF/ha)	325 000	
Gross margin (HUF/ha)	103 000	
Break-even yield (t/ha)	4.9	
Average total cost (HUF/t)	37 538	

Source: Author's own construction

As part of the cost-income analysis of the rape enterprise, the different types of costs were first taken into account. The costs of input materials are HUF 158,233/ha, 58% of all direct costs, the cost of machinery work is HUF 102 000/ha (38%), personnel costs related to the rape technology (e.g. plant pro-

tection consulting service) HUF 5,000 /ha (2%), other direct costs (e.g. soil sampling, precision data processing, data analysis and differential application mapping services) HUF 5,000/ha (2%) were taken into account (Table 7). The total direct costs were HUF 269,760/ha. With a yield of 3.5 t/ha and a typical market price of HUF 112,000/t during the examined period, the sales revenue was HUF 392,000/ha. The gross margin is HUF 122,000/ha, the break-even yield is 2.7 t/ha, the cost of production is approx. 85 000 HUF/t.

Table 7: Cost and revenue for the rape enterprise

rape		
Cost of input materials (HUF/ha)	158 000	58%
Cost of machinery work (HUF/ha)	102 000	38%
Personnel cost (HUF/ha)	5 000	2%
Other cost (HUF/ha)	5 000	2%
Direct cost (HUF/ha)	270 000	100%
Total cost (HUF/ha)	297 000	
Yield (t/ha)	3.5	
Sales price (HUF/t)	112 000	
Sales revenue (HUF/ha)	392 000	
Gross margin (HUF/ha)	122 000	
Break-even yield (t/ha)	2.7	
Average total cost (HUF/t)	84 857	

Source: Author's own construction

Table 8: Cost and revenue for the sunflower enterprise

sunflower		
Cost of input materials (HUF/ha)	127 000	58%
Cost of machinery work (HUF/ha)	71 000	38%
Personnel cost (HUF/ha)	5 000	2%
Other cost (HUF/ha)	5 000	2%
Direct cost (HUF/ha)	221 000	100%
Total cost (HUF/ha)	243 000	
Yield (t/ha)	3.5	
Sales price (HUF/t)	103 000	
Sales revenue (HUF/ha)	360 500	
Gross margin (HUF/ha)	139 500	
Break-even yield (t/ha)	2.4	
Average total cost (HUF/t)	69 430	

Source: Author's own construction

Regarding the analysis of the cost-revenue relationships of the sunflower enterpise, we found that the total direct costs are HUF 220,297/ha (Table 8). The cost of input materials (fertilizer, plant protection agent, seed) is HUF 126,999/ha, 58% of the total cost. The cost of machinery work is HUF 71 000/ha (38%), personnel costs are HUF 5,000/ha (2%), other costs are HUF 5,000/ha (2%). With an average yield of 3.5 t/ha and a sales price of HUF 103,000/t, the sales revenue is HUF 360,500/ha, the gross margin is cca. HUF 140,000/ha, the break-even yield is 2.4 t/ha. This enterprise produced HUF 69 430 /t as cost of production.

In the case of corn cultivation technology, the total direct costs are HUF 313 000/ha, of which the cost of input materials is 142,573 HUF/ha (47%) and the cost of machinery work is 160 000 HUF/ha (50%). Personnel costs are 5,000 HUF/ha (2%), other direct costs are 5,000 HUF/ha (2 %), (Table 9). With a yield of 10 tons and a selling price of HUF 45,000/t, the sales revenue is HUF 450,000/ha, the gross margin is HUF 137,000/ha. The break-even yield is 7.6 t/ha, while the cost of production is HUF 34,400/t.

Table 9: Cost and revenue for the corn enterprise

corn		
Cost of input materials (HUF/ha)	143 000	47%
Cost of machinery work (HUF/ha)	160 000	50%
Personnel cost (HUF/ha)	5 000	2%
Other cost (HUF/ha)	5 000	2%
Direct cost (HUF/ha)	313 000	100%
Total cost (HUF/ha)	344 000	
Yield (t/ha)	10	
Sales price (HUF/t)	45 000	
Sales revenue (HUF/ha)	450 000	
Gross margin (HUF/ha)	137 000	
Break-even yield (t/ha)	7.6	
Average total cost (HUF/t)	34 400	

Source: Author's own construction

Table 10: Cost and revenue for the grain sorghum enterprise

sorghum		
Cost of input materials (HUF/ha)	122 000	45%
Cost of machinery work (HUF/ha)	130 000	52%
Personnel cost (HUF/ha)	5 000	2%
Other cost (HUF/ha)	5 000	2%
Direct cost (HUF/ha)	262 000	100%
Total cost (HUF/ha)	288 000	
Yield (t/ha)	8	
Sales price (HUF/t)	45 000	
Sales revenue (HUF/ha)	360 000	
Gross margin (HUF/ha)	98 000	
Break-even yield (t/ha)	6.4	
Average total cost (HUF/t)	36 000	

Source: Author's own construction

In the case of grain sorghum, the total direct costs are HUF 262,000/ha. The cost of input materials is HUF 121,500/ha (Table 10). The cost of machinery work is HUF 130,000/ha (52%), the personnel cost is HUF 5,000/ha (2%), other costs are HUF 5,000/ha (2%). Calculated with a yield of 8 tons and a sales price of HUF 45,000/t, the sales revenue is HUF 360,000/ha, the gross margin is HUF 98,000/ha, the break-even yield is 6.4 t/ha. The cost of production is HUF 36,000/t.

Table 11: Cost and revenue for cropping structure with no sorghum

item	Winter wheat	Rape	Sunflower	Corn	Total
arable land (ha)	700	350	350	700	2 100
Direct cost (thousand HUF)	155 400	94 500	77 350	219 100	546 350
Sales revenue (thousand HUF)	227 500	137 200	126 175	315 000	805 875
Gross margin (thousand HUF)	72 100	42 700	48 825	95 900	259 525

Source: Author's own construction

In the case of grain sorghum, the total direct costs are HUF 262,000/ha. The cost of input materials is HUF 121,500/ha (Table 10). The cost of machinery work is HUF 130,000/ha (52%), the personnel cost is HUF 5,000/ha (2%), other costs are HUF 5,000/ha (2%). Calculated with a yield of 8 tons and a sales price of HUF 45,000/t, the sales revenue is HUF 360,000/ha, the gross margin is HUF 98,000/ha, the break-even yield is 6.4 t/ha. The cost of production is HUF 36,000/t.

Table 12: Cost and revenue for cropping structure with sorghum

item	Winter wheat	Rape	Sunflower	Corn	Sorghum	Total
arable land (ha)	700	350	350	350	350	2100
Direct cost (thousand HUF)	155 400	94 500	77 350	109 550	91 700	528 500
Sales revenue (thousand HUF)	227 500	137 200	126 175	157 500	126 000	774 375
Gross margin (thousand HUF)	72 100	42 700	48 825	47 950	34 300	245 875

Source: Author's own construction

Summarizing the enterpise cost and revenue analyses, the direct costs for 350 hectares of sorghum, 350 hectares of corn, 350 hectares of rape, 350 hectares of sunflowers and 700 hectares of winter wheat amount to HUF 528,500 thousand (Table 11). The total sales revenue is 774,375 thousand HUF producing the gross margin that is 245,875 thousand HUF. Thus, in comparison with the cropping structure with no sorghum (Table 10), it is 17,850 thousand HUF, that is, 3% less direct costs are incurred. At the same time, it gives less sales revenue by 4% and a lower sum of gross margin by 5%.

CONCLUSIONS

Sorghum is suitable for replacing corn in the crop rotation in areas with unfavorable conditions, so a stably growing crop can be added to the crop rotation of autumn ears of corn, rape, and sunflower instead of corn. We compare this with the effects of responses to the challenges that arise during farming. Such is the fact that the machinery and equipment pool does not hinder modernization efforts either, since the precision tools and developments already started in the corn production can be used well, and does not require a special tool park. At the same time, in light of the increasingly frequent negative climatic effects, its integration into the plant production structure is encouraging, because we have to count on 3-4 drought years in a decade. The stability of sorghum, its content values, and its quality parameters are increasingly making it an alternative to corn. It is justified to increase the weight of sorghum in the sowing structure, whether it is produced as feed material or for sale, completed by further investigation of its positive effects on farming. Based on our analysis, the inclusion of sorghum in the crop structure does not significantly reduce the income, which is acceptable in the given economic environment. However, its stability can significantly contribute to improving the resilience of farming, especially in comparison with corn.

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TECHNICAL EFFICIENCY OF DAIRY FARMS IN RURAL NIGERIA

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Abstract: *The study assessed the technical efficiency of Nigerian dairy farms. Information on 73 dairy farms was obtained from the General Household Survey (GHS Panel) for the year 2018-2019 wave, and the method of analysis employed include descriptive statistics and Data Envelopment Analysis Model. The findings show that not all the farms sampled are technically efficient, which means they can still utilize their input resources more effectively. The average level of technical efficiency of sampled farms was 83%; this suggests from the technical point of view that there exist an opportunity for expansion of milk production and revenue using the same level of inputs at present and putting to use effectively available technologies by 17%. Furthermore, results also show that farms that practice grazing systems, those located in the northern part of Nigeria and small farm sizes, have higher T.E. overall.*

Keywords: *Dairy farms, Nigeria, Technical Efficiency, DEA*
(JEL Classifications: Q12, Q1, R15)

INTRODUCTION

Dairy farming stands as one of the critical sectors in most countries' economies (Maina et al.,2018), and it is treated as one of the noblest activities, where it offers a regular and stable income as compared to other agricultural and allied activities (Jacob—Ambily, 2018). The sector provides employment and income sources for many, especially in developing countries. FAO (2010) evaluated households that lived on or within dairy farms and discovered that of the world's population, about 12-14 per cent falls into this category, accounting for 750-900 million people. The IFCN Country Profile collected for over 100 countries in 2015 shows that the growing size of farm and herds has fueled the growth in milk supply over the past decades. Dairy farms have been on the increase from 1996 to 2013, with a current number of about 118 million dairy farms across the world and each has an average of 3 cows and a mean yield of 2.2 tons of milk produced per cow annually (IFCN, 2015). Also, according to IDF 2013 report, the world altogether turned out approximately 621 million tons of milk from a cow in 2011 which was valued at 292 billion USD, this amounted to about 9 per cent of all agriculture products for that year. The World milk production for 2020 was projected to hit almost 860 million tons which is a 1.4 per cent increase from 2019 (FAO, 2020).

Nigeria, a developing and prominent country in Africa, is predominantly an agrarian country that provides a livelihood source for two-thirds of the populace and employs about 75 percent of the nation's workforce (IFAD, 2012). Nigeria has excellent opportunity based on its livestock population and large animal production capacity, with about 25 per cent of livestock herds leading livestock producers in Central and West Africa (Benard et al., 2010). The country's cattle herds are estimated to be 20 million heads in 2018; this stands for 1.36 per cent of the global total, putting Nigeria in the fourth position of largest cattle population in Africa after countries like Ethiopia, Sudan, and Tanzania, based on the U.N. Food and Agricultural Organization statistics. Out of the country's total herd, 11.5 per cent accounts for dairy, while about 88.5 per cent is consumed as meat. The country's meat consumption can be said to be low, this is especially true for pork meat, because pork meat has to face religious regulations (Vida – Szűcs, 2016), and customers' misbelieves (Vida, 2013).

In spite of all these substantial potentials, the Nigerian dairy sector is still far below expectation, the local milk production is less than 1 per cent of the total annual demand, estimated to be 1.45 billion litres (FAO, 2013). Exploiting the potentials needs higher level management and work organization solutions supported by strategic decisions (Felföldi, 2001). Nigeria's growing population is expected to expand swiftly in the next decades, with an anticipated population of almost 400 million by 2050. These would lead to high demand for livestock products and a projected per cent increase of 117, 253 and 577 in beef, poultry, and milk consumption, respectively (FAO, 2019). Dairy consumption in Nigeria is rising faster than the pace of production, leaving imports to fill the gap. The sector must be managed and organized to become effec-

tive and efficient (Apáti et al., 2005). The annual importation of food in Nigeria is accumulated to about 5 billion USD, and milk importation accounts for about 1.3 billion USD (NLTP, 2019). From the point of view of the quality food of the future, it is essential to develop and increase the efficiency of milk production (Kovács et al., 2021).

The national production of milk and dairy products in Nigeria presently stands at 0.5 million tons, just about 38% of the growing demand of about 1.3 million tons (FAO, 2019). This production is inadequate to satisfy the growing demand for the dairy product in Nigeria. The local production of dairy products is far below the annual demand making the Nigerian population's milk consumption less than 10 litres per head compared to the global average, which of about 40, 50 and 70 litres per head in South Africa, New Zealand, and the USA respectively, and in some African countries 28 liters per head (FAO, 2013). Indigenous cattle breeds represent over 90 per cent of the herd population in Nigeria, while the rest are cultured breeds imported from the Netherlands and other countries (Saleh et al., 2016).

Also, milk production in Nigeria is handled mainly by the pastoralist tribesmen called the Fulani who control over 90 per cent of the cattle population (Olafadehen—Adewumi, 2008), and the production is further hindered by the low level of cattle nutrition, poor milk yield and traditional method of processing milk products (Okeke et al., 2016). Despite the well-known fact that it has close relationship between cattle keeping and quality of milk (Nagy-Felföldi, 1999), production practices are grossly underdeveloped with many constraints affecting productivity, such as lack of modern dairy facilities and infrastructure, the poor genetic quality of local breeds limiting the potential for optimal milk production, high technology cost for cross-breeding of exotic cattle, the type of dairy system practised which is mostly pastoralism (Ugwu—Achike, 2010).

Consequently, this paper aims to explore the efficiency of Nigerian dairy production. More concretely, the study would seek to explain:

1. The profile of dairy farmers socio-economic characteristics in Nigeria
2. The technical efficiency level of dairy farms in rural Nigeria
3. Factors influencing the technical efficiency level of dairy farms

LITERATURE REVIEW

World milk production has been increasing, and it has been estimated that cow milk covers about 81 per cent of global milk and experienced a growth of about 1.3 per cent in 2019 to about 852 million tons (OECD/FAO, 2020). It was also estimated that global milk production in 2020 expanded by 1.4 per cent from 2019 and reached nearly 860 million tons; this reflected a positive production increase in crucial milk-producing countries like the USA, the E.U., Russia, Brazil, Pakistan, and India (FAO, 2020). India and Pakistan are essential milk producers worldwide, and they are estimated to supply over half of the global milk production growth in the next decade, accounting for over 30 per cent of global production by 2029 (OECD/FAO, 2020).

Table 1: Top 5 Milk producer countries in 2019

Country	Milk produced (' 000tons)
World	852,000
India	191,000
European Union	167,811
USA	99,057
Pakistan	47,297
Brazil	34,897

Source: FAO Dairy Market Review 2020

In the case of Nigeria, there is more than 20.6 million head of cattle which are primarily raised and controlled by the extensive system (FAO, 2018). The primary cattle production system existing in Nigeria, as seen in Table 2, is the intensive (modern), semi-intensive (agro-pastoral) and extensive (traditional) systems, which represent about 82% of the total population (UAA, 2011).

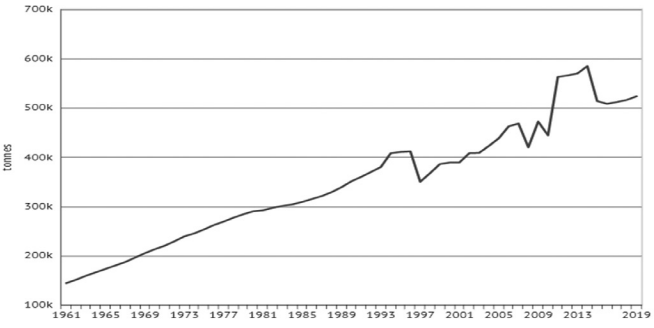
Table 2: Nigeria cattle production system as of 2017

Production systems	Number (heads)	Total population (%)
Extensive	15 111 309	82.1
Semi-intensive	3 089 804	16.8
Intensive	203 548	1.1

Source: Federal Ministry of Agriculture and Rural Development 2017.

In 2019, the milk production for Nigeria was 523,599, increasing from 213,000 tons in 1970 to 523,599 tons in 2019, growing at an annual rate of 2.01 per cent. About 5 per cent of local milk produced in Nigeria is from exotic breeds raised by commercial farmers such as Brown Swiss, Holstein Friesian, Jersey, and other crossbreeds, with an average milk production of 8 litres per cow per day (FAO, 2018). The current milk production in Nigeria does not meet the market demand of

Figure 1: Trend of Nigeria's Milk Production between 1960 and 2019



Source: Knoema 2020

about 1.45 billion litres annually (CSIRO Factsheet, 2018); dairy production is typically small-scale oriented, which is associated with low productivity: the average milk production annually is about 213 litres for a cow, this is below 1/10 the world milk production average (Makun, 2018).

Growth in agricultural productivity has been an effective way to maintain the sector as a significant source of economic growth (NPC, 2015); one way of increasing productivity is by improving the efficiency of production (Farrell, 1957). Measuring productive efficiency is an old concept pioneered by Farrell (1957), who showed how to decompose the economic efficiency of a farm into its technical and allocative efficiency components. Efficiency measures should be a priority area for dairy farmers to ensure that their farms produce to meet the competition efficiently for the national and, most significantly, international markets in a more sustainable way (Jafor, 2019). To measure efficiency is a difficult task, because efficiency can be measured in different ways, with different levels (partial, complex, social, corporate, regional and macro-economical) of indicators (NÁBRÁDI et al., 2008). To counteract the effects of urbanisation, it is necessary to maintain and develop those agricultural sectors that can provide an acceptable level of income for people living in rural areas on a relatively small area (Bittner-Kerékgyártó, 2012) Increasing the efficiency of these sectors is therefore an important aspect.

METHOD AND DATA

Nigeria lies between latitude 4o and 14o North and longitudes 2o and 15o East, covering a geographical space of 923,768 square kilometers. This study used secondary data obtained from the General Household Survey (GHS Panel) conducted in the 2018-2019 wave four by the Nigeria National Bureau of Statistics (NBS) Nigeria in collaboration with the World Bank Living Standard Measurement Study (LSMS) integrated surveys. For our research, information about agriculture was filtered and sorted out to obtain the desired sample population. 73 dairy farms with valid and complete information were selected for the sample data. The variables extracted from the main data set include the socio-demographic characteristics of dairy farmers, their geopolitical zones and most importantly, the production factors in dairy farming.

Efficiency always expresses the relationship between an output and input category (Nábrádi et al. 2009). Data Envelopment Analysis (DEA) was used to calculate the efficiency rate of dairy. This is the most important representative of the non-parametric methods for measuring efficiency, which use mathematical programming rather than regression (Oluwatayo—Adedeji, 2019). According to Charnes et al. (1978), the entities for which their efficiency scores were calculated was called Decision-Making Unit (DMU). They employed linear programming to obtain non-parametric, piece-wise frontier 'enveloping' all input-output combinations (production possibility set) for each DMU. DEA develops an empirical frontier function, which is determined by the most efficient producers of the observed dataset because efficiency is measured as the distance to this frontier; without considering statistical noise, DEA is a deterministic model. The significant advantage of this method is the flexibility due to its non-parametric nature, i.e., no assumption about the production function is required (Andor—Hesse, 2011).

The most applied and used model was done by Charnes et al. (1978); they proposed a model that had an input orientation and assumed constant returns to scale (CRS) to solve the following linear programming problem for each firm to obtain the efficiency score:

$$\begin{aligned} &\max_{u,\,v} && \mathbf{(u'yi / v'xi),} \\ &\text{constrains:} && \mathbf{u'yj / v'xj \le 1,} \quad j = 1, 2, ..., N, \\ &&& \mathbf{u, v \ge 0} \end{aligned} \tag{1}$$

Based on Coelli et al. (2005), some notations are defined. Assuming there is data on K inputs and M outputs from N firms. For the i-th firm, these are represented by column vectors xi and yi, respectively. X represent the K*M input matrix, while Y explains the M*N output matrix for all N firms. To obtain the efficiency measure, there is a need to measure the ratio of all outputs over all inputs, such as u'yi / v'xi, where u represents the M*1 vector of output weights, and v represents the K*1 vector of input weights. The values for u and v must be found such that the efficiency measure for the N-th firm is maximized, subject to the constraints that all efficiency measures must be less than or equal to one. One problem exists with the formulation because the model has infinite solutions. Charnes et al. (1978) added another constrain v'xi = 1 to help solve the problem, which provides:

$$\begin{aligned} &\max_{\mu,\,v} && \mathbf{(\mu' yi),} \\ &\text{constraints:} && \mathbf{v'xi = 1} \\ &&& \mathbf{\mu'yj - v'xj \le 0,} \quad j= 1, 2……, N, \\ &&& \mathbf{\mu, v \ge 0,} \end{aligned} \tag{2}$$

The change of notation from u and v to μ and v implies that this is a different linear programming problem. The reformation in (2) is known as the multiplier form of data envelopment analysis. From the above multiplier formula (2), the envelopment form is as follows:

$$\begin{aligned} &\mathbf{\min_{\theta,\,\lambda}\ \theta,} \\ &\text{constrains:} && \mathbf{-yj + Y\lambda \ge 0,} \\ &&& \mathbf{\theta xi - X\lambda \ge 0,} \\ &&& \mathbf{\lambda \ge 0,} \end{aligned} \tag{3}$$

where λ represents the vector of peer weights. θ is a scalar whose value obtained will be the efficiency score for the i-th firm. It satisfies $\theta \le 1$ when the value is 1 indicating a technically efficient firm. This linear programming problem must be solved N times, covering each firm in the sample. Each firm has its own θ value efficiency score (Coelli et al., 2005). The points at which firms are fully efficient to determine the fully efficient frontier line.

The assumption about the constant return to scale is only suitable if firms operate at optimal scale, which is often not so for firms with imperfect competition, government regulation, the constraint on budget, and many other factors. Banker et al. (1984) and other various authors suggested adjusting CRS

model to account for variable returns to scale (VRS) situations. The VRS model is similar the CRS model but for convex¬ity constraint N1'λ = 1, which is added to the model. This VRS approach by Banker et al. (1984) presents an output-oriented model, where firms have a fixed quantity of input resources, i.e., capital, labour, live¬stock and land, and want to produce output such as, milk and calf as much as possible. This model is similar to the input-orientated model. The formula of an output-orientated VRS model is the following:

$$\max_{\phi,\lambda} \phi,$$
$$\text{constrains:} \quad \begin{aligned} &-\phi\, yj + Y\lambda \geq 0, \\ &xi - X\lambda \geq 0, \\ &N1'\lambda = 1 \\ &\lambda \geq 0, \end{aligned} \qquad (4)$$

where ϕ is a scalar, λ is a Nx1 vector of constants, and N1 is an N*1 vector of ones, $1 \leq \phi < \infty$ and ϕ–1 is the proportional increase in output that could be achieved by the i-th firm, with input quantities held constant. 1/ϕ determine the technical efficiency score, which lies between zero and one. For this study, output-oriented VRS DEA was used to determine how much output the farmers would produce within the given input level.

The study used one output variable as the output-orientated DEA model- milk production revenue (values expressed in naira) while for the farm model, five input variables were as follows:

1. *Dairy cows:* It referred to the total number of cow head owned by the dairy farmers during 2018/19 production season and held for milk production.
2. *Feed Cost:* this refers to the total cost of fodder, concentrates, supplements, and watering of the dairy farm. (Valued in naira).
3. *Labour input cost* is the total cost of labour working on the dairy farm; this is expressed in naira.
4. *Veterinary cost:* The cost of animal health care during the 2018/19 production season expressed in naira.
5. *Other costs:* It is the overhead cost involved in dairy production to cover other expenses like energy cost, facilities cost, and storage cost, which is expressed in naira.

RESULTS AND DISCUSSION

Before presenting the results of the DEA model, Table 3 contains the descriptive statistics of the production variables used on dairy farms. It reveals the minimum and maximum cost of production within the 2018/19 production season.

Table 3: Descriptive statistics of production variables (N=73)

Variables	Unit	Minimum	Maximum	Mean	Std. Deviation
Milk Revenue	Naira	500	8 500	2 276.71	1 608.357
Dairy Cows	Number	1	200	11.15	24.800
Cost of Veterinary	Naira	100	16 000	3 006.58	1 682.307
Cost of Feeds	Naira	1 500	160 000	21 164.38	19 780.752
Cost of Labor	Naira	400	5 000	1 490.41	921.565
Operating Expenses	Naira	1 000	15 000	5 736.99	1 768.514

Source: Own's calculation based on the GHS (2018/19) data.

The efficiency of sampled DMU's scores in this study were presented on a scale of 0-1.00, where farms with a 1.00 score show that they are fully efficient with the current level of inputs they put into use while those with 0.0 score are inefficient,, with their input use.

Table 4: Estimated Technical Efficiency of Sampled Dairy Farms

TE Range	Frequency	Percent (%)
0.00-0.39	0	0.0
0.40-0.50	2	2.7
0.51-0.60	3	4.1
0.61-0.70	12	16.4
0.71-0.80	21	28.8
0.81-0.90	6	8.2
0.90-1.00	29	39.7
Total	**73**	**100**
TE estimates		
Mean	0.83	
Min	0.46	
Max	1.00	
Standard deviation	0.15	

Source: Own calculation based on the GHS (2018/19) data.

The results in Table 4 show that under the VRS model with output orientation, the mean technical efficiency of the dairy farms sampled was 83%, with a standard deviation of 15%. This means that an average farm in the sample could increase its level of milk production and revenue, using the same current input quantities by 17% through the proper use of input at its disposal more effectively without introducing external inputs and practices. The minimum and maximum efficiency levels were about 46 and 100 %, respectively; this shows that there is wide disparity among the sampled dairy farms in their T.E. It indicates that there is room for improving the existing level of milk production through improvement in the farm's technical efficiency.

Relationship of Feeding System, Geographical Zone and Farm size on Farm Efficiency

Through DEA VRS model using the output orientation it is aimed to examine if the feeding system (grazing vs main feed), the zone or location of farming and the farm size affect the farm efficiency.

Feeding System: The proper management of feeds is essential in dairy farms to boost the productive of dairy cows (Derib, 2010) hence the importance of feed in efficiency measures. According to the result from Table 5, the majority of farms 73% made use of a grazing system, also known as pasture, to feed their cattle, while the other 27% kept their cattle in a closed system and fed them with mainly feeds like TMR (contains blends of feedstuffs in a balanced ration with required nutrient level).

Using the VRS model, it was discovered that farms that practice the grazing system have a higher mean technical efficiency score of 84%, while farms that confine their cattle to feed have a mean efficiency of 79%. This means that an average farm that gives their cattle only feeds could increase their milk production and revenue by 21% with the level of the current input, while on the other hand those who use grazing/pasture systems can increase theirs by 16%. This result is consistent with Shkodra et al. (2020) findings which explain that farms that practice grazing systems have a higher T.E., happy and healthier animals, and produce good quality milk with lower costs incurred. They also explained that farms that use grazing hardly record problems associated with cow lameness, commonly encountered in closed-system farms. To further buttress the grazing system, it is essential to explain that the majority of cattle raised in Nigeria are under the pastoral / extensive type whose feeds mainly through grazing and practice nomadic system.

Table 5: Mean of VRSTE for the sampled farms based on feeding system.

Feeding System	Percent (%)	Mean VRSTE	Std. deviation
Grazing	73	0.84	0.16
Mainly feeds	27	0.79	0.15

Source: Own's calculation based on the GHS (2018/19) data.

Geographical Zone: Based on the zone categories, about 81% of the sampled farmers are from northern Nigeria; this population is higher than the southern counterpart, where just about 19% are represented in the study. This result is further supported by the findings of UAA (2011), which explained that cattle rearing is dominant and commonly practised in the northern part of the country, mainly because it is their principal occupation and source of livelihood. The technical efficiency of the geopolitical zones was calculated, as seen in Table 6. There is a significant effect, with the most efficient region being the Northern part of Nigeria, with mean technical efficiency of 84%. This means that dairy farms in this region used their resources effectively compared to the southern part of the country; this could be because dairy farming is one of their primary and important income sources in the northern part of Nigeria as against the south. In addition, the high level of experience in practice is another crucial factor that gives them a superior advantage (UAA, 2011). It was also discovered that they could increase their milk output and revenue by 16% if their input was more efficient. On the other hand, the southern part of Nigeria has a mean T.E. of 78%, meaning there is about 22% opportunity for them to increase their output at the current level of input and technology available at their disposal and use.

Table 6: Means of VRSTE of the sampled farms based on zone.

Gender	Percent (%)	Mean VRSTE	Std. deviation
North	81	0.84	0.16
South	19	0.78	0.15

Source: Own's calculation based on the GHS (2018/19) data.

Farm Size: The farm size was grouped into three categories based on the number of cows owned. About 89 % of the dairy farms have herd sizes between 0 and 20, and this category has the largest number of farmers; this explains that most are small-scale dairy farmers. 6.8 % of the farms are medium size and have a herd size of between 21 and 49 cows, while just 4.1 % have a cattle size of over 50 in number, and this category represents the large farm size within the scope of the study.

According to Table 7, the mean of VRS technical efficiency of each farm size was presented. Results under the DEA VRS model revealed that farm size influences T.E. Small farms ranging from 0-20 have a mean score of 0.84, meaning they have a T.E. of 84%. The possible reason for this could be that farmers in these categories combined their resources more effectively. Also, the mid-size farm has a lower score of 0.78 which means a technical efficiency of 78%, while large farms have a mean efficiency of 54%. There was a decline in the mean technical efficiency from small farms (0.84), which has the highest efficiency, to large farms, the lowest (0.54). This is a testament that most farms in the sample size are small-scale and maximize their resources efficiently. Also, from the result, small farms have about 16% opportunity to increase their output by fully utilizing their inputs at the current level of resources and technology. This result was contrary to the findings of Kovacs—Szucs (2020), where they discovered that large farms in Hungary have higher efficiency levels, and Shkodra et al., 2020 in their findings also confirmed that larger farms have more assets and consequently could produce more than small farms.

Table 7: Means of VRSTE for each farm size.

Farm Size	Percent (%)	Mean VRSTE	Std. deviation
Small (0-20)	89	0.84	0.15
Medium (21-49)	6.8	0.78	0.15
Large (50 above)	4.1	0.54	0.18

Source: Own's calculation based on the GHS (2018/19) data

CONCLUSION

This paper evaluated the technical efficiency of a dairy farm in rural Nigeria using the Data Envelopment Analysis (DEA) model to estimate the overall technical efficiency of each sam-

pled dairy farm in Nigeria using the variable return to scale (VRS) method. Different forms of input usage were presented based on production factors and the level of milk production.

The findings show that not all the farms sampled are technically efficient, which means they can still utilize their input resources more effectively. The average level of technical efficiency of farms sampled was 83%; this suggests from the technical point of view that there is an opportunity for expansion of milk production and revenue using the same level of inputs at present and using effectively available technologies by 17%. This result suggested that there can be an improvement in the productivity and efficiency of dairy farms in Nigeria if they practice their farming system more efficiently. Results also revealed that farms that use grazing systems scored better in technical efficiency than those that used feeds, small-size farms scored the highest level of efficiency under the VRS, and dairy farms located in northern Nigeria have higher technical efficiency scores than those in the south.

Conclusively, proper feed management should be encouraged, and farmers were seen to practice more of a grazing system to make this more efficient; they should seek to grow plants rich in proteins like soybean and incorporate ingredients that will aid cattle growth and milk production. Also, government and policymakers should establish working policies that would support grazing land availability to cattle owners, most especially in the Northern part of Nigeria, where cattle are reared and raised.

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POTENTIAL IMPACT OF THE EUROPEAN GREEN AGREEMENT ON EU AND HUNGARIAN CROP PRODUCTION

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Abstract: *European arable farming, including Hungarian arable farming, faces a huge dilemma: how to contribute to and maintain the global food supply while reducing greenhouse gas emissions while main taining biodiversity, but reducing inputs that are potentially damaging to society and the environment while ensuring that no more land is taken out of production? Not to mention that the increasingly urgent need to tackle climate change is also placing additional demands on EU agricultural decision-makers. Under the European Green Deal (GD), the 'From Farm to Fork' (F2F) strategy will help achieve climate neutrality by 2050, with a target of a 55% reduction in greenhouse gas emissions by 2030. Achieving this will require significant changes in food production, a shift in crop health strategies and accelerated innovation in the agricultural sector. The study addresses these issues. Our first hypothesis (A1) is that the GD and F2F strategies can be implemented without problems and without losses. Our second assumption (A2) is that the know-how solutions and the technological conditions for precision agriculture that are already available exist, and that all of these already justify the feasibility of A1. In order to prove this, we have reviewed recent and up-to-date literature on DG and F2F. For A1, we found that there are pro and con findings in the literature. However, the summary finding is not positive. The conclusion of the studies, based on data calculations, is that EU agriculture faces huge additional costs if it is to maintain production and reduce environmental pressures. Their calculations suggest that more people will be disadvantaged by the decisions, and that millions of euros could be lost to the public. However, the article also shows that there are many cases where positive results can be achieved even with reduced chemical use. Facts and figures from international and Hungarian technological and know-how solutions and their trials at plant level show that the DG's objectives are already partially achievable. It has been established that the systematic use of precision technologies allows to increase the natural and at the same time the economic efficiency. In our work we have used the results of primary and recent secondary research. We have shown the downsides of GD, but also that with targeted support, the objectives of sustainability and GD can be approached. Changes in 2022, drastic price increases for inputs including fertilizers and pesticides, inflation at a 20-year high, energy prices spiraling out of control, and an almost unprecedented drought affecting crop production and horticulture, point to the need for a radical change in technology, thinking and regulation. And all this to ensure that there is enough affordable food in Hungary, that there are export products within and outside the Community, and that those working in agriculture have a decent living.*

(Jel Code: O13, Q15)

INTRODUCTION

Established in 1962, the Common Agricultural Policy (CAP) has absorbed more than 40 percent of EU expenditure. The original objectives of the CAP were to increase productivity, provide a fair standard of living for the farming community, stabilize markets and ensure sufficient food for European consumers. Since its introduction, the CAP has undergone a number of changes, with the main objectives being given a new emphasis, including food safety, animal health and welfare, and then environment and nature protection. The main policy objectives of the new CAP for the second decade of the 21st century are: to ensure a fair income for farmers; to improve competitiveness; to improve the position of farmers in the value chain; to take action on climate change; to protect the environment; to preserve landscapes and biodiversity; to support generational renewal; to stimulate the rural economy; to protect food quality and health; to improve knowledge and innovation. In parallel with these objectives, a new political reflection on sustainable development has been launched among EU policy makers. This has resulted in new policies and action plans. These include the European Green Deal (GD), the Next Generation EU, the EU Biodiversity Strategy, the European Forestry Strategy and finally, in May 2020, the Farm to Fork (F2F) strategy for agriculture.

The European Green Deal was presented by the European Commission in December 2019, declaring that Europe will become a climate neutral continent by 2050. Following the publication of the Communication (11 December 2019), legislation has been launched in a number of areas, with legislative changes expected in climate targets, energy, transport, environment, agriculture and industrial policy (COM, 2019). It is perhaps interesting to note that seven years ago it was said that "greening" per se does not attract much attention among agri-food business leaders unless it is coupled with an end to economic waste". At least, this was the view in 2015 (Zokaei et al., 2015). The European Commission presented its proposal for the adoption of a climate agenda in March 2020, followed by the adoption by European leaders in December 2020 of a new target for the EU to reduce net EU carbon emissions by at least 55% by 2030. The European Parliament and Member States reached a political agreement on the European

Climate Action Plan in April 2021, and the regulation entered into force in June 2021. It also included strategic targets for biodiversity. The areas that affect agriculture are:

1. at least 30% of EU land is designated as protected areas;
2. limit urban sprawl;
3. reduce the risk of pesticides;
4. restore at least 10% of agricultural land with high landscape diversity;
5. 25% of the EU's agricultural land should be farmed organically;
6. make progress in restoring contaminated land;
7. reduce soil degradation and
8. plant more than three billion new trees (Montanarella and Panagos, 2021).

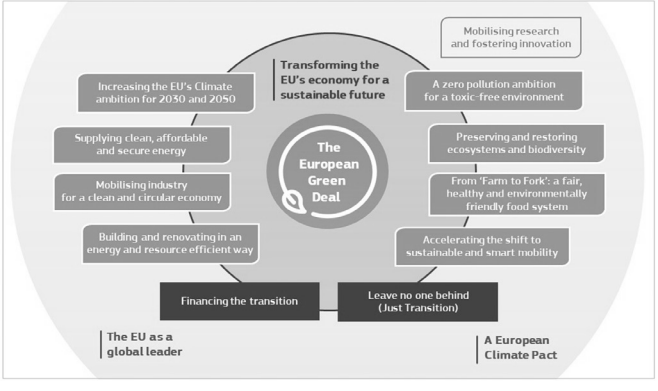
Following the climate change agenda, the European Commission presented the "Soil to Table" F2F strategy in May 2020, one of the key actions of the European Green Deal. Aimed at achieving climate neutrality by 2050, the strategy declares that

1. reduce pesticide use by 50%,
2. reduce fertiliser use by 20% by 2030.
3. it also foresees a 50% cut in antibiotics,
4. and would increase the proportion of land under organic farming from 8 to at least 25% (Basics of a rethink of the farm to fork strategy, 2021).

As several authors have argued, F2F can be linked to the UN Sustainable Development Goals (SDGs) by having as one of its main objectives the reduction of negative environmental, social and economic externalities associated with the production of food and drink (Capozzi et al., 2021). On 19 October 2021, the European Parliament voted in favour of the report on the Farm to Fork Strategy presented by the European Commission, giving the green light to start the legislative work needed to achieve the objectives of the strategy.

The European Green Deal addresses several priority areas, of which four broad groups are easily identifiable and Figure 1, which promotes the implementation of the deal, provides a very comprehensive picture of these areas.

Figure 1: Areas of the European Green Deal



Source: COM, 2019

One of these areas is clean energy, which means that if the targets are met, energy consumption will fall by 36% and the share of renewable energy will rise to 40%. The EU energy embargoes on Russia, extended in June 2022, are likely to hamper the timely achievement of the target. The renewal of buildings, including the energy modernisation of public buildings, will also contribute to increasing the use of renewable energy. Sustainable transport aims to significantly reduce carbon emissions, so only new cars with zero emissions are expected to be on the road by 2035. The fourth call to action is to work with nature, which foresees the planting of three billion new trees and includes the sustainable use of biomass. In the light of the GD and F2F regulations, we believe that the Green Deal will have the greatest impact on agriculture in terms of arable crops and their yields and production efficiency. The F2F strategy's objectives to be met by 2030 include a strong set of standards for environmental sustainability. All of these have a direct or indirect impact on arable crops. In our study, we want to analyse whether it is possible to prioritise environmental sustainability, which is otherwise very sympathetic, and whether this is compatible with social and economic sustainability. We will explore the literature, the tools, technologies and empirical experiences that are potentially available to achieve environmental feasibility.

Research assumptions on the topic:

A1: Our first assumption is that the GD and F2F strategy is feasible without problems and without losses.
A2: Our second assumption is that the know-how solutions and the technological conditions for precision agriculture that are already available are given, and that all of these already demonstrate the relevance of the GD's requirements.

METHODOLOGICAL ISSUES OF LITERATURE PROCESSING AND RESEARCH

Secondary research methodology

The following methodology was used to process the international literature on the topic: first, the topic and keywords were searched for "Green Deal" in Clarivate Web of Science, one of the largest databases available online. The result was 8079 hits. These publications were published between 1982 and 2022, and in terms of number, mainly in the last 5-7 years. For this reason we changed the starting year from 1982 to 2015. As a result, the number of articles has been reduced to 5240.

We then took two steps to narrow down the number of publications: on the one hand, we further reduced the time interval and, on the other hand, we restricted the subcategories of Web of Science.

The narrowing of the time interval was linked to the publication of the Green Deal, i.e. we searched for publications from 2019 onwards. The main focus of our work was not the scientific preparation for the development of the GD, but its potential impact on EU and Hungarian crop production. In 2019, 692, in

2020 928, and in 2021 1256 publications were about the Green Agreement. In 2022, the number of publications increased further with 464 papers.

In terms of subcategories of publications, 978 papers were on environmental science, 446 on green sustainability and 118 on economics.

In order to identify the rather large number of publications and their disciplinary "clusters", we have again carried out a narrowing down. Here we have used the Rayyan interactive software for literature processing. The software is designed to provide the analyst with keywords and summaries of articles and to exclude possible duplications. Following the timing of the EC and EP decisions, we have specified the co-occurrence of the terms Farm to Fork and Green Deal keywords between 2019 and 2022. The result was only 37 hits in June 2022. The 37 publications were then processed. Where the keywords and abstract of a publication were found to be relevant to the title of the study, they were collected separately and downloaded in full to the computer if deemed necessary. Following the downloads, a detailed literature review of our article was carried out.

Primary research database

KITE Zrt. has offered technologies and proposals for greening in line with GD and F2F expectations well in advance of policy decisions. Practice preceded political decisions, the development of theories and the laying of the necessary theoretical foundations were and are still being done with a practice-oriented approach, today the possibilities offered by IoT, cloud-based information flows, data mining, mobile internet have at least quintupled the possibility of information flows and availability in 10 years.

Intelligent sensors in agricultural machinery capture a wealth of data that can be used as the basis for complex spatial and temporal, technical and agrotechnological analyses. This data is generated in John Deere's proprietary system, stored in the on-board computer (monitor) of the power machine or synchronised directly via remote data transfer to the MyJohnDeere portal, where the consultant and/or farmer can evaluate/analyse the information required. Following the collection of the so-called documented operational data, KITE Zrt. carried out a comprehensive study between 2012 and 2013 based on its own measurements to measure, analyse and quantify the development of inputs and incomes of different cultivation technologies (conventional, precision, band). The studies have included a more penetrating study of fuel use, labour input, nutrient replenishment, differential number of plants and input requirements for crop protection.

The study used technological data from a farm of more than 2000 ha. These data are based on exact measurements, as the modern power and working machines of the test farm have a sensor capability that continuously documented certain machine diagnostic and agronomic (input material yield and harvesting) parameters. The recorded data were extracted from the on-board computer of the tractor/combine and subjected to technological and tabular analyses. Much of the extracted data can be interpreted as spatial information, as modern technology allows the GPS system to document coordinates. The traditional precision and banding technology mentioned earlier was also carried out using GPS to capture the data. The spatial and temporal information also allows for a breakdown below the table level, although no such (crop) site-specific analyses have been carried out. The labour time input and specific fuel consumption were calculated as a function of the number of runs of the technology, based on technical discussions with the agronomic manager of the company concerned.

The data were compared with the AKI (Institute of Agricultural Economics) Test Farm Information System, which monitors the wealth, financial and income situation of Hungarian commodity-producing agricultural enterprises on a yearly basis through a representative sample of 2100 farmers. The system is mandatory for EU Member States, but farms are required to provide data on a voluntary basis. In addition to farm-level accounting and production data, sector-level cost and income data are an important part of the system in Hungary (Keszthelyi and Molnár, 2015).

Specialised geospatial software (SMS Advance and ArcGIS) was used for the data sorting (data cleaning, data filtering, spatial interpolation, tabular data aggregation) from the test farm of KITE Zrt. and Microsoft Office™ and SPSS for the basic statistical analyses.

LITERATURE PROCESSING

Recent publications show that there is agreement among green policy-makers on the GD and F2F provisions, but also negative opinions. In their study, Baquedano et al. (2022) predict that policies restricting the use of agricultural inputs have been shown to reduce production, farmers' incomes and increase food prices, which may ultimately lead to increased food insecurity. Estimates have been made for the EU and the world. Their results show that, compared to the current situation, input constraints will lead to a net increase in food insecurity, affecting 30 million people (EU only) and 171 million people (global) by 2030.

The European Commission's Farm to Fork (F2F) strategy under the European Green Deal recognises that innovative techniques, including biotechnology, can play a role in increasing sustainability. At the same time, organic farming will also be promoted, and at least 25% of EU farmland should be farmed organically by 2030. How can biotechnology and organic farming be both developed and promoted to contribute to achieving the Sustainable Development Goals? The increase in organic production envisaged in the F2F strategy could lead to a less sustainable food system policy, not a more sustainable one. The authors of this research (Purnhagen et al., 2021) have raised questions that are clearly aimed at EU policy makers, but also perhaps at the sustainable development community. These were:

1. How can a regulatory framework be developed that allows the combined benefits of organic farming and biotechnological innovations to be harnessed?
2. How can effective communication be developed to demonstrate that many biotechnology breeding innovations do not violate the organic principle of cell integrity?

3. How can effective policies be developed to address the conflicting objectives of the EU Commission's F2F strategy?
4. Which features of organic farming contribute to and/or threaten the achievement of the SDGs?

Which characteristics of biotechnological innovations can help address the weaknesses of organic farming in achieving the SDGs? (Purnhagen et al., 2021)

A further analysis of the related literature reveals that sustainability is increasingly becoming a priority in EU policies, especially in the Common Agricultural Policy. These include those focusing on the Sustainable Development Goals (SDGs), the European Green Deal and the F2F strategy, and those that attempt to establish links between all these and the EU's trade policy (Pietrzyck et al., 2021).

The European Green Deal, F2F and biodiversity strategy set the scene for the future review of the Common Agricultural Policy (CAP). The CAP will address an increasing number of objectives, including the contribution to the Sustainable Development Goals and the Paris Climate Change Agreement. To enable evidence-based policy making and monitoring, the Farm to Fork strategy proposes to extend the current monitoring system to a wider range of sustainability issues. The monitoring system of the Farm Accountancy Data Network (FADN) places a strong emphasis on financial and economic data. The FADN is a tool for monitoring and evaluating the EU's Common Agricultural Policy and collects accounting results from 80 000 farms. The expansion into a Farm Sustainability Data Network (FSDN) should include a wider range of indicators on farm sustainability performance. This document estimates the costs of this wider collection of sustainability indicators in the FSDN, based on the experience of the pilot project in 9 Member States and a survey of all Member States. The results show that collecting sustainability data from all farms in the FADN would increase costs by around 40%. The results show large variations between countries depending on the current costs of data collection and the expected additional work involved in including sustainability indicators. Given the high demand for this data, a scenario has been developed in which sustainability data is collected from a sub-sample of 15 000 farms. This could be achieved within the current budgetary constraints by reducing the INHH sample from 85 000 to 75 000 farms. The discussion section addresses some of the concerns raised about the extension of the FADN to FSDN, such as the willingness of farmers to use the FADN, the administrative burden on farmers, the need to maintain the FADN and the need to ensure that the FADN is not overly burdensome.

How do we measure progress? EGD theory has also inspired researchers to develop new analyses and indices. For example, (Dabkiene et al., 2021) proposes the introduction of the Agri-environmental Footprint Index (AFI) as an indicator to determine the current state of the environment and to monitor changes and outcomes on farms. The subject and its scope are so broad that it includes the circular economy, a subset of the bio-economy. Some authors argue that in order to recover nutrients from nutrient-rich wastes, attention should be directed towards treatment processes that lead to the production of mineral fertilizers that can be further utilized. The Commission strongly recommends this as part of the F2F strategy, which is an integral part of the EGD. An interesting approach is taken by Lalander and Vinneras (2022), where they describe how insects are nature's waste managers and can play a vital role in closing the loop of nutrients returned from society to the food industry, thereby reducing the environmental impact of our food production system, as is the aim of the EU's F2F strategy. Insects can be used to convert biodegradable waste into biomass that can be used as food or animal feed, thus linking waste management to food production. However, food safety regulations prevent around 70% of the food waste available in the EU from being used as a substrate for insect breeding. In order to reap the true environmental benefits of insects as an alternative source of protein, a legal and hygienic framework must be found to allow insects to be reared on mixed food waste in the EU.

Another new area is the issue of pesticides. More people are feeling the challenge of what is implied by GD and F2F. Biodiversity by 2030 is a strategic challenge for the evaluation and authorisation of pesticides, where risk management will be a key element for the approval of active substances and the authorisation of pesticides (Molteni and Alonso-Prados, 2020).

IT is the next key issue for the implementation and enforcement of GD and F2F. There is a saying that "the greatest inhibitor of any change is the human element itself". Almost all elements of the EU's GD require basic digital skills. People with IT skills look at digital technologies as an opportunity for a sustainable future. People working in agriculture and living in rural areas who do not have such skills do not recognise the digital transformation process and treat it as an enemy (Rijswijk et al., 2021). It is likely that in this area, too, there is a need for training and broad information to increase the capacity to adopt and accept digital skills.

The Covid pandemic affected the world in a way and to a degree that few could have predicted, causing severe disruption in many industries. Despite this, crops were sown and harvested, food was produced and agriculture continued to function, albeit with many logistical challenges. European arable farming faces a dilemma: how to contribute to and sustain global food supply while reducing greenhouse gas emissions, not reducing biodiversity, but reducing inputs that are potentially damaging to society and the environment, while ensuring that no more land is taken out of production? In Europe today, it is not only the Covid epidemic but also the increasingly urgent need to tackle climate change that is driving change! Under the European Green Deal, the F2F strategy promotes climate neutrality by 2050 and aims to reduce greenhouse gas emissions by 55% by 2030. Achieving this will require significant changes in the way food is produced, a shift in plant health strategies and accelerated innovation in the agricultural sector. Such results have been reported by researchers in the areas of crop protection and nutrient replenishment.

Bryson (2022) discusses how the use of synthetic fungicides contributes to plant health and the management of greenhouse gas emissions. It also explores future challenges and prospects for their positive contribution to achieving global food security, while using new innovative technologies.

In particular, the F2F strategy aims to reduce the use of pesticides and mineral fertilisers, but also supports the development of organic farming. At the same time, food demand is increasing. These ambitious challenges require extensive research, development and innovation. Therefore, new non-chemical techniques to improve plant growth and resilience to biotic and abiotic stresses need to be explored for their potential in this area. One of the most promising is the use of non-thermal plasmas for such purposes. As this physical agent is a complex mixture of ions, atoms, electrons, radicals and molecules, its effects on plants and pathogens are complex. Pańka et al. (2022) reviewed the literature and found evidence for the potential use of non-thermal plasma for plant growth enhancement and crop protection.

Wesseler (2022) concludes that F2F strategy as part of the GD reduces agricultural production in the EU and causes food prices to rise. This is expected to further increase consumer price inflation in the EU and beyond. However, farmers' incomes in the EU are not expected to fall in the near future. The F2F strategy could result in a redistribution of subsidies from consumers to farmers in the EU. On average, studies evaluating the economic impact of the F2F strategy show a reduction in welfare (economic) and, strange as it may seem, well-being (economic and social) in the EU due to the implementation of the F2F objectives. However, the studies do not fully quantify the environmental and health benefits of the F2F strategy, but they do include well-being. It remains doubtful whether the environmental and human health impacts will be sufficient to offset the expected welfare losses. Similarly, Wesseler (2022) is of the opinion that there are also doubts about the logical consistency of the F2F objectives and targets, and their relationship with the objectives of the GD and the nCAP. A reduction in agricultural production in the EU could lead to spill-over effects in regions outside the EU, which could undermine the objectives of the GD.

Achieving the objectives of the F2F strategy (limiting the use of herbicides) is expected to increase the work and expenditure on soil cultivation. Tillage is associated with an increase in greenhouse gas emissions. The impact of the F2F strategy on reducing greenhouse gas emissions, which is the main objective of the strategy, remains highly debatable. Although studies evaluating F2F have reported positive effects on greenhouse gas emissions, changes in land use practices have not been explored. The positive impact of the F2F strategy on food security is also questionable. Studies that have looked at crop emissions have predicted a decline in EU production and an increase in food prices. Cereals, but also other 'over-populated' crops, are at higher risk of production because of their lower disease resistance due to their very high 'potential yield'. The reduction in pesticide use limits the ability of crops to respond to biotic and abiotic stresses and to withstand extremes. This is expected to reduce food security for low-income households within the EU and reduce the EU's contribution to food security abroad (Montanarella and Panagos, 2021).

The impact of the F2F strategy on biodiversity is difficult to assess. Different forms of agricultural production and product production have different impacts on biodiversity. Whether the impact will be positive or negative depends on how biodiversity is measured. The use of measures that take into account the number of species and a certain frequency of species may not result in higher levels of biodiversity in line with the objectives of the F2F strategy. A more detailed assessment would require a ranking of species values, which raises the question of how the ranking is implemented and how civil society is involved. One study used a biodiversity indicator and reported positive impacts on biodiversity at the farm level (Beckman et al., 2020).

The assumptions and implications discussed above are based on the assumption that no further drastic institutional-strategic changes are expected after the introduction of GD and F2F, and that technological developments and innovations will be subordinate to them. According to Wesseler (2022), in the longer term, the F2F strategy is expected to lead to a reallocation of input factors, increasing the efficiency of production and distribution in EU agriculture. However, these changes will take time and it is clear that the policy level can influence the length of time over which these changes take place. A reallocation of factors could be facilitated by a reduction in restrictions on land swaps or foreign direct investment inside and outside the EU. Technological change can be supported by reducing the time needed to approve alternatives to chemical pesticides and providing stronger incentives to use modern biotechnology to address the many challenges facing crop production. It is in the hands of EU policy makers to transform the F2F strategy into a prosperity-enhancing strategy by implementing the necessary institutional changes.

The EU's F2F strategy, launched in 2020, also aims at a comprehensive sustainability transition of the European agri-food sector. However, as the strategy itself acknowledges and various impact evaluations (Barreiro-Hurle et al., 2021; Beckman et al., 2020; Henning et al., 2021; Noleppa and Cartsburg, 2021) have shown, political will alone will not achieve ambitious targets. Success depends to a large extent on innovation, both scaling existing innovations and developing entirely new ones (Reinhardt, 2022). To support these, consider first the results presented by Beckman et al. (2020) (Table 1).

Table 1: Estimated impacts in the EU and the world following the F2F and Biodiversity Strategies under different scenarios up to 2030

Scenario		Producers incomes changes in, %	Consumer Expenditure change, USD/ person/ year	GDP change in, billion USD	Food- Change in the number of people living in insecurity, million persons
EU adaptation	EU	–16	153	–71	–
	Word	+2	51	–94	22
EU+ EFTA-adaptation	EU	–8	651	–186	–
	Word	+4	159	–381	103

Source: Beckman et al. (2020)

The estimated effects in the EU are clearly projected to be a fall in producer incomes in the range of 8-16 percentage points, an increase in consumer spending in the range of USD 153-651 per capita per year, and a fall in GDP of USD 71-186 billion. To make matters worse, the number of people living in food insecurity worldwide could increase by 22-103 million.

However, it should be noted that the economic evaluation of agricultural policies is not a trivial task. Any economic evaluation model is a simplification of reality; it may therefore contain uncertain assumptions. Nevertheless, models can help by providing information on the possible consequences of policy choices. In the EU, new legislation and policies require impact assessment, including forward-looking studies under the Better Regulation programme, to ensure, in the Commission's words, evidence-based and transparent EU legislation based on the views of stakeholders. However, not only one but several applied models have been developed for evaluating EU agricultural policies. However, they differ in terms of the time and space dimensions they cover, the detail of the sectors they cover, and their environmental and other impacts. This was reviewed in the study by Varacca et al. (2020). As reported by Wesseler (2022) in the European Commission's Joint Research Centre, models for assessing the impact of EU agricultural policies are maintained and continuously updated. One of the widely used models is the Common Agricultural Policy Regional Impact Assessment (CAPRI) model, which is used for ex ante impact assessment of agricultural and international trade policies. Barreiro-Hurle et al. (2021) and Henning et al. (2021) used the CAPRI model to assess the impacts of the F2F strategy. Noleppa and Cartsburg (2021) used the multi-market model described by Lüttringhaus and Cartsburg (2020) and Beckman et al. (2020), the GTAP-AEZ (Global Trade Analysis Project - Agro Ecological Zone) multi-regional, multi-sector, computable general equilibrium model to assess the impact of the F2F strategy. The evaluation of the F2F strategy by Bremmer et al. (2021) combined case studies for ten crops from seven countries (Finland, France, Germany, Italy, Poland, Romania and Spain) with the AGMEMOD (Agricultural Member State Modeling) partial equilibrium model.

Table 2: Results of studies on the impact of the F2F strategy on agricultural production, % in the EU

Cereals	Oilseeds	Vegetables, fruits, plantations	Fodder crops	Beef and veal	Dairy products	Sources
−15,0	−15,0	−12,0		−13,0	−10,0[d]	Barreiro-Hurle et al., 2021
−48,5[a]	−60,7	−5,2[c]		−13,5	−11,6	Beckman et al., 2021
−18,0[a]						Bremmer et al., 2021
−23,6	−7,3	−13,0	−30,0	−17,0	−6,0	Henning et al., 2021
−26,0[a]	−24,0[b]					Noleppa et al., 2021

[a]Only wheat, [b]Only rape, [c]Only vegetables and fruits, [d]Pour milk
Source: Wesseler (2022)

One of the challenges of modelling the F2F strategy is to combine different objectives, as the effects overlap. For example, increasing organic farming already includes reducing the use of chemical pesticides and mineral fertilisers.

Farm to Table and Biodiversity strategies, as we have seen, have been subject to a number of impact assessments. In his work, Wesseler (2022) has processed the findings of F2F strategies reported by different groups of authors. Two summary tables from his work are presented here (Tables 2 and 3).

Table 3: Results of the study on the aggregate economic impact of the F2F strategy

Farm income	Food expenditure	GDP	EU production value, billion EUR	Authors
Growing	Growing	Decreasing		Barreiro-Hurle et al., 2021
–16%	153,2 USD/fő	–84,2 milliárd USD[d]		Beckman et al., 2021
Decreasing			–140	Bremmer et al., 2021
+35,08 billion EUR	70 billion EUR[b]	Decreasing	Growing	Henning et al., 2021
>15 billion[a]	Growing[c]	Decreasing[c]	Decreasing	Noleppa et al., 2021

[a]Only crop production was considered and calculated for 2040, [b]Expressed as total consumer surplus, [c]Indirect inference from the decline in production and the general model description, [d]Only in EU case
Source: Wesseler (2022)

The studies consider different scenarios, which examine the impacts of the Farm to Table (F2F) and Biodiversity strategies on EU agricultural production, production prices and external trade in the food economy, in addition to welfare impacts. They also quantify the expected environmental impacts and mention the spill-over effect. Detailed methodological and implementation exercises can be found in the original study.

The studies conclude, as already mentioned, that the new regulation is expected to have negative impacts on EU agricultural production, production prices, external trade of the EU food economy and welfare effects, but that the expected environmental impacts are positive even if the spill-over effect is taken into account.

In the light of the above, we do not consider our first assumption (A1) that "the DG and F2F strategy can be implemented without problems and without losses" to be justified. The results of five modelling exercises all indicate that the new regulation has negative impacts in most measurable cases (production, output prices, foreign trade, welfare). However, the studies do not quantify the environmental and health benefits of the F2F strategy. It is doubtful whether the effects on the environment and human health will be sufficient to offset the expected welfare losses. However, we have also seen that there are a number of promising novel existing research results

that can be put in the bag of GD proponents. It should also be noted that all the studies essentially start from an analysis of past time series and calculate absolute yield reductions for expected impacts for different agricultural sectors. This can also be explained by the fact that it does not take into account the effects of technological responses to changes in rules, improvements on yields, input use and production efficiency.

THE RESULTS OF PRIMARY RESEARCH

Machinery, machinery connections, installed equipment, modern genetic background, IT developments and with them digital solutions are taking off in agricultural production. The adaptive technologies used have evolved significantly over the past decades, leading to improvements in efficiency on both the yield and input sides. All these factors together mitigate the expected negative effects of the F2F strategy, and in themselves represent partial compliance with the European Green Deal.

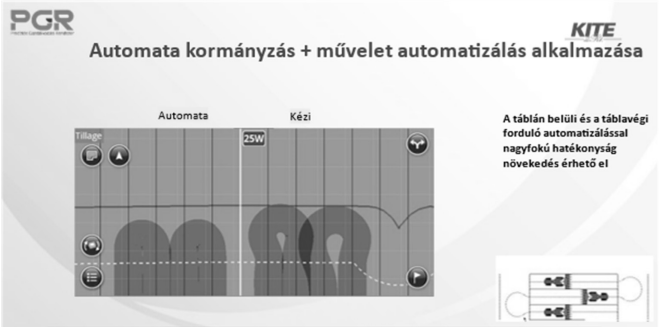
Arable crop production deserves special attention, since the improvement in natural efficiency is not only measurable, but can also be documented thanks to modern information technology solutions.

Today, agriculture is one of the leading sectors in terms of the practical application of the latest IT developments, mainly due to the use and application of circuits, displays, information technology tools, AMS devices, sensors, chips, automatic electro-pneumatic and hydraulic systems built into agricultural machinery and the use of geo-information systems, including positioning systems.

The first milestone in the technological development of conventional field crops and cultivated over large areas was the emergence of positioning systems and their subsequent use in agriculture.

These systems make it possible to carry out the operations required for successful cultivation technology more quickly, over a large area, in a repeatable manner (in space and time), without overlapping and without skipping, and accurately and efficiently, even over large working distances, provided that the opportunities and capabilities offered by the improvements made by the machine manufacturers (e.g. automatic steering) are used professionally by the personnel operating the machines. Automated steering and the automation of certain technological operations alone can be expected to result in fuel savings of at least 5-8%, which will go hand in hand with a reduction in emissions and an increase in operational efficiency.

Figure 2: Positive benefits of automatic steering



Source: KITE Zrt.

The advent and use of section control allows the separation of yes/no operations. Section control allows that, when certain technological operations are carried out, the machine carrying out the technological operation can not only apply the input material over the full working width by using the positioning systems built into the machine and direct communication between the machine and the implement, but can also pause the application of the input material in the area already treated or not requiring treatment, based on signals sent by the machine. A glaring example is when some of the nozzles on the spray wheel of a power-trailed sprayer, controlled by an on-board computer, are deactivated as it passes over the crop once treated, resulting in further operational efficiency improvements and input savings of between 2-7%.

The next step in precision technology is to combine certain technological operations to achieve a reduction in the number of passes, a good practical example of which is the combination of seedbed preparation, band spraying, soil disinfectant application, seeding and starter fertilisation in one pass. The combined technology described above can be carried out with a combination of power-driven machines and seed drills, which, in addition to saving fuel and inputs, meets the requirements of soil conservation technology (less disturbance, dusting, soil treading) and allows better use of inputs.

The use of machine couplings for differentiated and positioned input material delivery will bring further natural efficiency gains. Instead of averaging, the savings on the input side can be as high as 50% if the inputs are applied differentially within the field, at doses and positions adapted to the site conditions, to the specific needs of the crop, optimised to achieve the intended yield target.

Both in the area of crop protection and in the area of nutrient supply, there are examples (positioned band weeding, positioned mechanical weeding with differential and positioned N application, differential nutrient supply based on management zones) where some interventions offer additional benefits on top of the real savings. A typical example in maize is liquid N applied in combination with intercropping and positioned in the root zone of the crop, when an inhibitor is used, as the input savings are associated with a reduction of losses and an improvement in input utilisation.

The principle of differentiation must be applied to all technological interventions (variable depth tillage, nutrient replenishment, seeding, crop protection) in order to achieve a synergistic effect, so that the application of systems thinking in practice leads to the greatest possible natural (and therefore, unchanged yields) and economic efficiency gains.

The above statements are supported by quantifiable data and comparisons based on KITE Zrt.'s own test results, which can also be measured in terms of natural efficiency, and which will be presented using the example of fodder maize cultivation technology.

Between 2012 and 2013, KITE Zrt. measured and quantified the specific fuel consumption of different maize cultivation technologies (strip-tillage, loosening and ploughing) in

its own studies. Analyses were carried out at 11 sites on 198 plots with different soil types (sandy loam, loam, loamy loam and clay) and different pre-crop types (maize, soybean, winter wheat, sunflower, rape and mustard used as green manure). The study was carried out in sunflower and maize crops.

However, when fuel consumption data were analysed, significant differences were found, not only due to technology but also to soil texture (Table 4).

Table 4: Fuel consumption for a given cultivation mode, l×ha^{-1}

Soil texture	Fuel consumption for a given cultivation mode		
	Strip-tillage	Decompaction	Ploughing
Sandy loam	10,2–11,3	12,7–14,2	21,9–23,6
Trough	11,8–12,9	14,6–16,7	24,8–27,8
Clay- loam	13,2–14,6	17,2–19,8	28,2–31,8
Clay	14,7–16,9	20,2–23,5	32,1–35,7

Source: KITE Zrt.

When comparing the different technologies, the specific fuel consumption (expressed in litres per hectare and per hectare) resulted in a 15% saving (overall average) when using the more soil-friendly (loosening) technology, whereas for strip-till the same value was 30%, resulting in a difference in fuel use per hectare of grain yield (assuming the same yield levels) of more than 5 litres/tonne, which is more than 40 litres/ha even at an average yield level.

In the current economic climate, with rising production costs, high crop prices and yield depression (yield side losses) due to extremely dry weather, the success of certain crops may depend on the amount of fuel used in the implementation of the technology.

The study also included a measurement and comparison of the labour time input per hectare of the cultivation technologies. In terms of operational characteristics, there was no significant difference in area performance for different soil types for a given technology:

- for strip tillage: 2.8-3.3 ha/h,
- 2.5-2.9 ha/h,
- ploughing: 1,5-1,6 ha/h.

Compared with conventional ploughing-based technology and strip-till technology, this represents a saving of more than 50% in working time. The difference is partly due to the reduction in the number of passes (combined operations) and partly to the efficiency gains resulting from the use of positioning systems and, in conjunction with this, automatic steering and the automation of certain technological operations (no overlap and no skip, section-controlled implement-machine linkages). If the analysis is carried out on a pre-sowing basis, it can be seen that, depending on the type of cultivation, the working time and thus the cultivation costs are reduced by around 11-14% for late pre-sowing.

By examining the relationship between the technology used and the specific input use, and measured in natural terms (fertiliser kg/ha, seed/ha, maize herbicide l/ha), it can be concluded that the use of precision technology resulted in input savings of between 5 and 10% compared to conventional technology, while specific yields were not reduced compared to the average of the AKI test farm.

Even higher savings can be achieved if the technology is extended to all crops in the rotation. Obviously, it is worth taking into account that a change in technology is associated with an increase in intensity, which is also reflected in higher yields, especially when a large proportion of the crops in the rotation are switched from dry to irrigated management.

Compliance with the GD is already partly ensured from a technological point of view, but the biggest challenge is still to meet food safety requirements and expectations, which for arable crop farmers means that the biggest change in the near future will be in crop protection.

In addressing the challenges as opportunities, the importance of foresight-based crop protection interventions should be emphasised, taking into account the opportunities offered by biological control and the changes and developments in chemical and mechanical weed control.

Forecast-based interventions are best supported by applications and web-based interfaces that process and analyse data from meteorological stations and complement them with pathogen and pest forecasts.

The justification and timing of interventions have a major impact on the effectiveness and success of the technological intervention, as well as on the amount of pesticide applied and the total amount used in the whole production technology. Repeated interventions due to unwarranted or poorly timed interventions result in additional expenditure, making it difficult to meet the quantitative targets set out in the Farm to Fork strategy.

In the biological pesticides market, a number of R&D and manufacturing agreements have been concluded in recent years and tens of mergers, acquisitions and joint venture agreements have been implemented. With the agrochemical giants spending an estimated hundreds of millions of dollars a year on development, biological solutions are slowly but surely emerging for a growing number of pests and pathogens, while weed control is still relying on conventional chemical solutions or mechanical weed control. For example, biological fungicides are now available, or biological fungicides are increasingly being used effectively against fusarium aphid in cereals, with the same efficacy as chemical products, and can therefore fully replace chemicals. However, the replacement of pesticides used for postemergence weed control in maize by biologicals is not yet feasible, leaving the use of row crop cultivators as an alternative to chemicals.

The amount of pesticide used and applied is strongly influenced by the method of application and the technical and technological development of the machinery and equipment used for application. The emergence of drones opens up new horizons, both in terms of pre-application surveys and application, which also makes it possible to achieve savings of up to 20% in kind.

The latest precision sprayers, whether self-propelled or towed, are equipped with sensor cameras under the banner of “smart spraying”, capable of detecting and distinguishing be-

tween crop and weeds, so that they only apply herbicide when the sensor camera passing over the weed signals the sprayer nozzles, allowing a 50% reduction in the dose of herbicide used or applied compared to a conventional sprayer.

In the field of mechanical weed control, new methods and machines have also emerged in the last few years, so the use of laser weed control, weed killers and weeding robots, which still seem futuristic, could be an alternative to chemical weed control.

All in all, a key condition for the implementation of the European Green Deal and its strategy for agriculture, which will have an impact on it, is that all the players in the sector are aware that meeting the challenges requires systems thinking and documentation.

A systems approach is understood to mean the principles of precision farming, which in the case of conventional arable crops are: right time, right place, right amount, right materials, right tools, right method.

As all technological interventions can be documented by artificial intelligence in machines, newer and newer IT solutions, the use of applications for the digital transformation of agriculture, the use of the internet, the only question is how quickly can we meet the challenges of the future? Namely, the fact that production is essentially determined not by yield expectations but by sustainability standards. This is partly the reason for the rise in production costs and the concomitant increase in the need for expertise and knowledge of decision support systems. And the authors of this study are happy to note that a deep interest in information technology is, after all, a concomitant of technological development and increased efficiency, whether natural or economic!

SUMMARY

Many of the forecasts presented in this paper, in part or in full, give contradictory results. Some argue that in the F2F strategy proposed by the European Commission, the given input reductions would lead to a reduction in EU agricultural production and competitiveness in export markets. According to these reports, under the current agricultural production process, changes resulting from reduced use of agricultural inputs in the strategies would lead to higher food prices, lower consumer and therefore consumption, and, strange as it may seem, lower GDP.

Our first assumption that "the GD and F2F strategies can be implemented without problems and without losses" is not correct and cannot be accepted. They are confirmed by the results of the model calculations presented in the secondary research. The impact mainly affects EU Member States, predicting a decline in GDP and economic welfare and well-being.

Seeing the increase in input prices and overheads, which are now global and have an impact on the direct and indirect costs of agricultural production as well as on the food industry, coupled with a prolonged dry period in 2022 in several European countries, we forecast a dramatic increase in food prices. At the time of writing, we had not even considered that a seemingly bilateral (Russia-Ukraine) war would have global impacts. What effects might this have? In our view, even without restrictions, there could be temporary, local and even product-specific shortages in market access for a particular product. We do not want this to happen.

A shortage of supply can lead to price increases at the same level of demand, since for basic foodstuffs, meeting demand from imports has a price-driving effect. As well as slowing supply chains, the cost of overseas and inland transport has risen significantly over the past few years due to rising energy prices, and energy prices are set to spiral out of control from 2021. The second assumption, A2, which was that "the know-how solutions and the technological conditions for precision agriculture that are currently available are already in place, and that all these factors together already confirm the feasibility of assumption A1", is a cross-cutting issue. We must acknowledge that this is not true. More knowledge, techniques and technologies are already available to support the objectives and expectations of DG and F2F. However, a large "group" of "necessary conditions" is missing from the repository of feasibility. The conditions are also composed of several segments: political conditions, macro- and micro-economic conditions, corporate-financial, but also, and emphatically, human resource conditions in addition to all economic conditions.

Among the studies, we found one source (Beckman et al., 2021) that examined the amount of agricultural productivity growth that would be needed to compensate for input limitation. Evidence from the empirical literature suggests that it would take 2-3 times the 10-year period of strategies to develop and transition to new technologies. In this context, while avoiding production losses and food price increases, the only way to achieve the expected reduction in input use is to make the necessary investments in the short term and to extend the timeframe by 10-20 years. As the study points out, it may be worthwhile to make the necessary investments as soon as possible to facilitate the introduction, dissemination and widespread use of modern, efficient technologies. Thus, it is worth targeting support for investments in precision technologies, the services, training, knowledge transfer, forward-looking development and research needed to use them, as further increases in input, labour and other costs are expected in addition to sector-independent energy increases.

In addition to the successive price increases (which are reflected in almost all cost items), the direct efficiency gains induced by the short payback investments in subsidised crops will allow the use of modern crop-specific cultivation technologies adapted to the needs of the crop, aiming at yield maximisation. If the maintenance or increase in specific yields is combined with cost efficiency, the sector's performance, profitability and competitiveness will improve. Higher consumption and increased investment will boost the contribution of growing exports to GDP. This will reduce the EU's dependence on food imports, while reducing the amount of inputs and chemicals used through the application of sustainable, modern and environmentally sound technologies. This will also reduce the direct and indirect environmental impact, in particular in terms of air pollution, as the unit of agricultural output will be produced with less and less carbon dioxide emissions.

The benefits of the strategies for the environment and human health are a subject of ongoing debate in the literature, mainly because of the way in which the environmental costs and benefits associated with the strategies are measured. The modellers noted that the changes estimated therein are based on large structural policy shocks, but could not have anticipated that Covid would still constrain market processes, could not have anticipated that the Russian-Ukrainian war would override sustainability and energy management policies, and could not have anticipated that global climate change would come drastically to European countries in 2022.

Strategists have introduced incentives to adopt new technologies and innovations. It is assumed that the adoption of these technologies will help to mitigate the productivity impacts of the input reductions introduced by the strategies. Although the details of these targets are not fully defined, they deserve more attention. However, current high-technologies are unlikely to be sufficient to compensate for the production losses resulting from the magnitude of the reductions in agricultural inputs. A de facto treadmill of agricultural technology adoption, together with insufficient R&D stocks and spending, pose clear challenges for future productivity growth and feeding a growing population. This raises concerns about the feasibility of EU strategies in the proposed roadmap and the consideration of the steps needed to create a more sustainable food and agriculture system.

As a final reflection, we believe we can agree with Beckman and colleagues' view that ultimately a strong and resilient food system can benefit from greater investment in innovative agricultural R&D. Where, ultimately, sustainability is achieved through continuous adaptation to new and unique challenges through science, innovation and adoption by farmers in their own fields around the world (Beckman et al., 2021). However, we also see that there is a huge challenge in agriculture. It will take hundreds of people from universities, research institutes and agribusinesses to meet the challenges and make a living from agriculture in the next decade, if at all!

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DECENT EMPLOYMENT AND POVERTY ALLEVIATION FOR SOCIO-ECONOMIC DEVELOPMENT AND ITS IMPLICATIONS FOR THE WELL-BEING OF THE CITIZENRY IN SOUTH AFRICA

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Abstract: *The need for governments and private employers to adequately provide decent work within the economy for all its inhabitants cannot be over-emphasized. This imperative is even more important since most obtainable work have been characterized by many detrimental dimensions which can be considered as constituting 'indecent employment'. From the viewpoint of human development, the paper examines how 'decent employment' can serve as an antidote to poverty. Thus, decent employment can positively affect both material and non-material social development which include health, education, social security, food security and overall well-being.. The present paper is borne out of the desire to empower the average South African citizen in specifically attaining an improved socio-economic living standard. This paper employs a qualitative, thematic analysis of selected reported cases of perceived 'indecent' or non-meaningful employment from both informal and formal sectors' Additionally, this paper highlights instances in which employees have experienced challenges in getting 'dignified' or decent employments as a result of casualization, outsourcing, short-term contracts, and temporary employments. This interpretive, qualitative approach was adopted to put forward a somewhat empirical evidence of the potential beneficial effect of decent employment on human and socio-economic development. The main contribution of this paper is that it foregrounds the need for decent employment of the workforce in addressing the three-pronged societal challenges of unemployment, inequality and poverty. The paper posits that decent employment significantly contributes to national socio-economic development and poverty alleviation or eradication.*

Keywords: *Decent Employment, Poverty Alleviation, Socio-Economic Development, Casualization, Outsourcing, Short-term contract, Temporary Employment.*

INTRODUCTION

'Indecent' employment practices lead to inadequacy in the sense that a seemingly employed individual is unable to meet the minimum needs for a minimum standard of living. In order to fulfil societal obligations in areas such as health, education, social security, and food security, productive employment is always a means of achieving material as well as non-material social development (ILO, 2011). In this paper, and consistent with the conceptualisation of ILO (1999), Deranty and MacMillan (2012), and United Nations Sustainable Development Goal 8(UN SDG-8), 'decent employment' or 'decent work' is seen as 'the desire of people in the world of work (whether formal or informal) to be adequately financially, materially or otherwise 'compensated' sufficiently to cater for their personal well-being and also to be able to make positive contributions to society therefrom'. Furthermore, in this write up, the terminology or phrase 'decent employment' and 'decent work' are used interchangeably to refer to the same concept. Meaningful or decent work has long been widely acknowledged as one of the main avenues available to persons through which they can escape poverty. Thus, as Narayan, Chambers, Shah, and Petesch (2000) aver, decent employment should provide adequate and secure standard of living amongst it other monetary and psycho-social benefits. They go on to argue that productive work that helps workers to avert poverty is a universal desire of workers (Narayan, et al, 2000). Whilst it would appear, in some instances, that people are employed, a closer examination would reveal that a significant proportion of such employments are casual, out-sourced, short-term and/

or temporary. This situation is compounded when one adds the nature of employment in the informal sector where cases of inhumane treatments and employment insecurity abound (Bell & Newitt, 2010). Thus, it can be argued that poverty alleviation through employment goes beyond the mere provision of work opportunities to include providing decent employment that address the negative elements and factors associated with work. It is this holistic approach, it is believed, and that would lead to socio-economic development and alleviate or eradicate poverty. With the above in mind, therefore, this paper attempts to explore how decent employment can be examined by first addressing the concerns over widespread poverty, disempowerment and racial inequalities that pervade the South African society. The question then arises, in what ways can decent work contribute to alleviating or eradicating poverty in South Africa? Have historical racial inequalities negatively affected the ability of the majority of South Africans to find decent employment? Is decent employment likely to have a positive impact on South Africa's socioeconomic development? If all these initiatives are considered together, what implications will they have for the well-being of South Africans? In the paper, many of these questions are answered for a better understanding of the subject matter.

AIM OF THE STUDY

The aim of this paper is to examine if decent work can contribute to alleviating or eradicating poverty and thereby to improving the socio-economic development of society and the well-being of individuals. Along with this aim, an attempt would be made to look at how the legislative efforts pertaining to decent wages, safe working conditions and the protection of labour right have fared in shaping decent work in the country. This paper hopes to determine whether decent work can eradicate poverty among South Africans by providing a sustainable income for an average resident and his or her family. To achieve this, however, financial investment in citizens, particularly the most vulnerable ones among the people in South Africa, should be a priority to improve their standard of living. Studying this issue relates to improving the effectiveness of government policy to deliver decent work that includes decent wages and salaries as well as ensuring safe working conditions, providing job security and protecting labour's rights. By completing the study, it aims to produce fruitful work for women and men that promotes good health, food security, affordable education, and human dignity. Programs and public policy interventions that will increase decent employment in South Africa should continue to be made available to everyone within the country.

LITERATURE REVIEW: 'DECENT EMPLOYMENT': AN OVERVIEW

Di Fabio & Maree (2016), cited by Somavia (1999), well-defined decent work as a productive occupation that protects workers' rights, produces adequate incomes and social security and provides employment that is sustainable (Di Ruggiero, Cohen, Cole,, & Foman, 2015). Decent work, according to the United Nations (2006), means the ability to choose freely a job, the recognition of basic rights at work, adequate social protection, and an income adequate to meet basic economic, social, and family needs. It is possible to achieve these goals without compromising workers' rights or quality of life. Significant differences have resulted from defining decent work and poverty differently (Dhakal, & Burgess, 2021). As part of decent work, one has the right to work, the freedom to choose a job, and favourable working conditions. It also includes the right to equal pay for equal work, safe and healthy working conditions, and opportunities for adequate self-construction (Rantanen, Muchiri, & Lehtinen, 2020).. The promotion of social dialogue is crucial to ensuring decent work, self-determination, fair and sustainable development, health, and well-being, gender equality, and the realization of one's potential. Poverty is defined explicitly as the following things: deprivation, deficits, indigence, poverty, paucity, privation, denial of human rights, social exclusion, stigmatization, powerlessness, anxiety, impairment of self-identity, anger, shame, guilt, sadness, loss of autonomy, and well-being (Kolot, Kozmenko, Herasymenko, & Štreimikienė, 2020).

As stated in article 23 section1 of the Universal Declaration of Human Rights, the United Nations' approach to full employment and decent work calls for every individual to have a good job, to freely choose employment, to enjoy equitable and just working conditions, and to be protected from unemployment (UN Report, 2007). The definition of decent employment recognizes that employment is a catalyst for more than just income, but also for dignity, family stability, peace within the community, and economic growth that allows for more productive jobs and employment (Cohen & Moodley, 2012). According to Wilson (1996), obtaining stable and secure work is related to physical and mental well-being as well as greater cohesion in communities (Paul & Moser, 2009; Swanson, 2012). The aspirations of people are best summed up by decent work. This includes productive and equitable work, a safe working environment and social safety nets for families, opportunities for people to achieve their potential and participate in society, freedom of speech, organization and participation in the decisions affecting their life, and equity for women and men (ILO, 2011).

As identified by the International Labour Organization, there are basic principles of decent work that need to be adhered to, such as: enhancing the standards and rights of employees at the workplace, protecting rights, dignity, equality, and fair labour practices in the workplace; enhancement of job quality through the creation of new jobs and the improvement of pay prospects; the eradication of poverty and inequality demands; the creation and expansion of collective security and social safeguards; promoting public discussion and negotiation between employees, employers, and the government (ILO, 2021). These outlined principles of the International Labour Organisational establish a connection between decent employment and poverty alleviation or eradication in societies. In support of this the South African government has pledged its commitment to the attainment of decent work and sustainable livelihoods for all workers and has undertaken to mainstream decent work imperatives into national develop-

ment strategies. It is imperative for policy makers to find solutions that help improve the living conditions of their citizens. It is vital to develop strategies to improve the socio-economic environment as part of the campaign for decent work.

PROBLEMS AND CHANLENGES OF DECENT WORK IN SOUTH AFRICA

The South African employment environment has not been spared the challenges highlighted above in spite of the 'democratisation' of the political system since 1994. Some of the challenges can be traced back to the residual effects of the prior, pre-democratic socio-economic dispensation which had institutionalised racial inequalities and disparities in employment. To address these, the post-apartheid government has attempted to enact various labour or employment legislation. The impact of these legislation on employment and socio-economic development have been varied. A visible short-coming of these efforts is reflected by the high rate of unemployment amongst the youth, increasing casualization and outsourcing of employment. One argument that has been advanced for this continued dire state of affairs in employment in South Africa is that the levers of control of the employment landscape in South Africa is yet to be 'democratised'. As a corollary to this argument is the need for both the government and private sector employers to provide meaningful, honourable and well-paying jobs that are able to meet the basic socio-economic needs of workers. Jobs that are not able to meet these needs end up having the unintended effects of engendering negative health and nutritional outcomes, and of further impoverishing the population. The increasing general population poverty rate in the country has been correlated to wage inequality and burgeoning rate of dependency of the population on government's social welfare schemes (Isaacs, 2016).

Venter and Levy (2014) identify high crime rates, social unrest, racial and gender disparities as additional factors that contribute to the malaise of indecent work in South Africa. It has been documented that these disparities negatively affect working persons and their families and the national economy. The absence of a national minimum wage policy have not helped the situation either. Even though the Basic Conditions of Employment Act of 1997 allow some vulnerable sectors to set minimum wage. Recognizing that the minimum wage alone cannot solve the nation's wage inequality or poverty problems, the National Minimum Wage level must be cognizant of the 'living wage' necessary for a dignified life (Isaacs, 2016). Based on the low-earning profiles of majority of South African families, it is clear that current wage levels do not meet the needs of families and are not sufficient to raise families out of poverty. In the bottom half of households with a wage earner, wage income constitutes the primary income source (Isaacs, 2016).

The efforts by the government, since 1994, to address these issues from a macroeconomic policy standpoint have included the implementation of the National Development Plan and the establishment of the Decent Work Commission (Venter & Levy, 2014). Unfortunately, in spite of these initiatives, the economy of South Africa has continued to experience low level growth and a persistent increase in unemployment as a result of numerous rigidities of economic and employment reforms (Johannes, 2012). Having productive employment is essential for achieving fair globalization and reducing poverty (ILO, 2015). The International Labour Organization (ILO, 2015) has developed a community of work agenda that centres on job creation, workers' rights, social protection, and social dialogue, with gender equality as one of the crosscutting objectives (ILO, 2015). It has become a universal human right to be able to work decently, and has been incorporated into major human rights declarations.

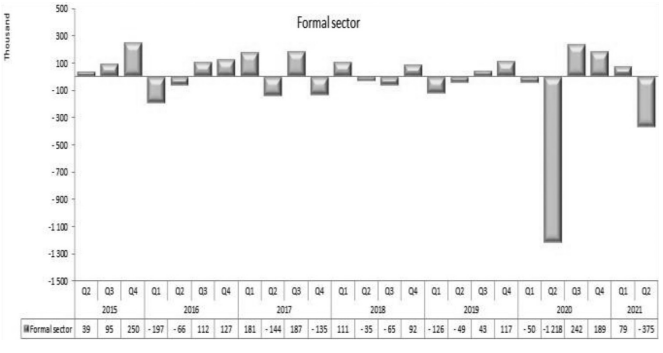
As stated earlier, while many efforts have been made, little has been accomplished due to the high levels of unemployment. The rise in joblessness in South Africa has not been addressed. This situation somewhat negates any efforts toward ensuring decent employment because people have to be gainfully employed, in the first place, before concerns over decent employment can have relevance. Thus, for example, the scrutinisation of the 'fairness' or otherwise of a contract of employment or an analysis of the quality of the work experience can only make sense if individuals have a job to begin with.

A SYNOPSIS OF EMPLOYMENT AND UNEMPLOYMENT PATTERNS IN SOUTH AFRICA IN THE LAST DECADE

Historically, the informal and formal employment sectors have dominated the South African labour market. Informal sector employment involves individuals that engage in largely unregulated, and sometimes hazardous employment while the formal sector is often the standardised and regulated form of employment. The informal sector has have been growing compared to the formal sector that has experienced some stagnation due to existing labour market policy within South Africa's employment environment (Altman 2002a; Edwards 2000; Meth 2001).

A summary of the South Africa informal and formal sectors is provided in the chart below. According to the report, there were job losses in five of the eight formal sector industries in South Africa. There was a decline in employment in some aspects of the formal sector as follows: the financial sector (229 000 jobs), community and social services (151 000

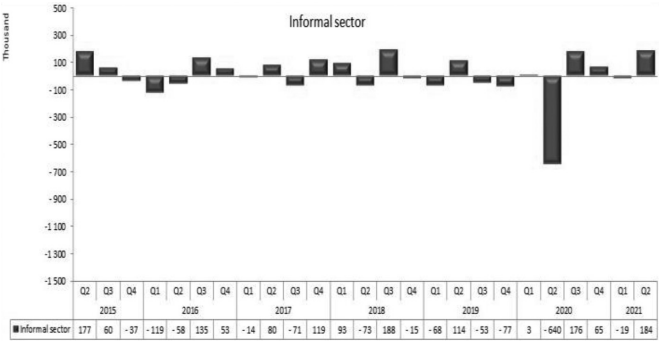
Table 1: Trend of Formal Sector in South Africa (2015-2021)



Source: Quarterly Labour Force Survey, Quarter 2: 2021

jobs), manufacturing (105 000 jobs), trade (42 000 jobs), mining (2 000 jobs), and Construction (112,000 jobs). Curiously, the Transportation sector (316,000 jobs) recorded the highest job gains, while Utilities saw no change in employment.

Table 2: Trend of Informal Sector in South Africa (2015-2021)



Source: Quarterly Labour Force Survey, Quarter 2: 2021

The representation of the South African formal and informal sector employment patterns in the above chart indicates that while there was an overall decrease in informal sector employment in Q1: 2021 (19 000 jobs), employment in this sector grew by 184 000 jobs in Q2: 2021. Formal sector employment declined by 375 000 jobs in Q2: 2021, compared to Q1: 2021. The formal sector employment in Q2: 2021 grew by 136 000 jobs compared to last year, driven primarily by the Construction (115 000 jobs), Community and Social Services (42 000 jobs), Transport (33 000 jobs), Mining (23 000 jobs) and Utilities (4 000 jobs) industries.

Despite political, economic, and demographic changes, the prevailing employment arrangement in South Africa can be traced to the era of apartheid and the post-apartheid period. During the apartheid regime in 1970, employments were based on racial disparity and discrimination. Then, most formal employment opportunities were reserved predominantly for the white population to the exclusion of all other population groups. This practice created a large swathe of the population that was unrepresented in the workforce. The policy also created a huge skills gap in the population (Venter & Levy 2014). Towards the end of the 1990s, the post-apartheid era saw the promulgation of far-reaching legislation, programmes and policies to redress these past imbalances.

Recent research in South Africa has shown that economic growth has demanded more skilled workers than unskilled workers. Thus, the policies of the pre-democratic period turned out to have resulted in labour force deficits which the post-1994 democratic government has had to grapple with. These short-comings needed to be addressed alongside considerations for providing decent employments that incorporate fair labour practices that are in line with the ILO principles. In this respect, therefore, the employment situation in South Africa continues to be constrained while efforts are being made to create the right environment for the emergence of adequate workforce that would take advantage of decent employment opportunities in society.

THE INTERSECTION OF UNEMPLOYMENT & POVERTY IN SOUTH AFRICA

The trend of poverty across African nations, particularly in South Africa is quite alarming and this can be attributed to unproductive and precarious employment. Poverty in South Africa can be viewed in a broader context as being more widespread amongst black persons, the uneducated, the, female-headed households, large families, and children. The prevalence of poverty has been determined to have a strong spatial dimension in South Africa, a demonstration of the enduring effect of apartheid (World Bank, 2014).

Following the radical constitutional change in South Africa, the government has been compelled to design a number of programmes and policies for reducing poverty, improving access to basic services, education, health care, social protection, and economic opportunities. This in turn helped to reverse some of the adverse effects of the system of segregation and deprivation under apartheid. However, this development is being weakened by the country's low economic growth prospects (World Bank, 2014).

As depicted in the report of the World Bank Document "Overcoming Poverty and Inequality in South Africa" (2018), South Africa also has a high concentration of low-income earners (the "poor") and a few very high-income earners (the "rich" or "elite"), but only a small number of middle-income earners. This has resulted in a high level of income polarization (Finn, 2015). The World Bank Group Poverty and Equity Report (2020) emphasised that 55.5 per cent or roughly 30.3 million people of the population is living in abject poverty while about 13.8 million, that is 25 per cent, are currently experiencing "sustenance poverty" in South Africa. Correspondingly, poverty is measured at the international poverty line of $1.90 and $3.20 per person per day (Bello, 2006; PPP, 2011). As it is often said that 'virtuous occupations' are the panacea for poverty reduction, alleviation and eradication within any society, the South African government policy interventions, such as the Labour Relations Act (LRA) of 1995, the Employment Equity Act (EEA) of 1998, and the Basic Condition of Employment Act (BCEA) of 1997, suggests that their impact on inequality, and thus on poverty, has been very modest. Creating good jobs for the poor will have a much larger impact on inequality and poverty.

Poverty is rooted in unemployment and underemployment. The poor are often unable to improve their quality of life without the income they earn through work. In order to reduce poverty and ensure sustainable economic and social development, it is necessary to create productive ('decent') employment opportunities. Providing decent jobs for women and young people, especially, is crucial for securing income and empowering the poor (UN Report, 2007). An expansion of the economy under circumstances of rapid growth can increase the number of productive and remunerative jobs, which can decrease poverty levels. Although economic growth is important to poverty reduction, it is not the only factor. The distribution of income will be determined by the ability of the poor to respond to the increasing demand for labour in more

productive job categories. The above illustration and many more have underpinned the subject matter of decent employment and poverty alleviation in the current paper.

IMPLICATIONS OF UNEMPLOYMENT AND POVERTY FOR SOCIO-ECONOMIC DEVELOPMENT

Unemployment and poverty are global phenomena that the government of each state must combat with the determination of eradicating the menace from the society. Not only does unemployment exist in many countries, it is very rampant in South Africa and has been a major cause of poverty in society. Creating jobs must occupy a central place in national poverty reduction strategies given the importance of employment in reducing poverty (Mafiri, 2002). A number of employment strategies are often connected to agricultural and regional development, such as promoting micro projects in rural areas and using labour-intensive agricultural technologies. In addition to promoting self-employment, non-farm employment in rural areas, targeted employment interventions, microfinance and credit as resources for skill development and training, are some additional strategies that encourage individuals to become self-employed (OECD, 2008).

The problem with such strategies, however, is that they commonly address the quantity of employment while overlooking or underestimating the qualitative aspects such as equity, security, dignity and freedom. Generally speaking, national poverty reduction strategies do not address decent employment principles such as, social protection, or worker rights. Social perspectives on development promote the view that decent work is the most effective means of achieving socio-economic development, eradicating poverty and enhancing personal wellbeing. In order to achieve international development goals, including the Millennium Development Goal of halving extreme poverty, productive employment opportunities are critical (UN Report, 2007). Better and more productive jobs should be created, especially those that can absorb the high concentrations of low-wage workers. A few elements are necessary to create such jobs. They include investing in labour-intensive industries, such as agriculture, promoting a shift in employment structure to more productive sectors and occupations, and improving employment quality in the informal economy. The provision of skills and assets to the poor is also imperative. Consequently, the poor will be able to fully capitalize on any expansion in employment possibilities (UN Report, 2007).

METHODOLOGY

In order to collect data for QLFS, Stats SA introduced a computer-assisted telephone interview (CATI). The same sample used in Q1: 2020 was also used in Q2: 2020, Q3: 2020, Q4: 2020, and Q1: 2021. COVID-19 restrictions that restricted the movement of the general population were eased prior to the data collection of the QLFS in Q2: 2021. Q2: 2021 was able to rotate samples due to this. Data from the labour market was used to select samples of households. Data on the labour market activities of South Africans aged 15 and over are collected and analyzed through a survey. Nevertheless, this report includes a section that discusses occupations for people aged 15 to 64. Due to COVID-19 and movement restrictions, Stats SA suspended face-to-face surveys on 19 March 2020. This was done to prevent field staff and respondents from being exposed to Coronavirus. Furthermore, the overlapping sample (i.e. rotation groups 1, 3 and 4) and the new sample were able to collect telephone numbers face-to-face from Q1: 2020. The data for QLFS Q2: 2021 was only collected from dwelling units for which contact numbers were available, which is why not all dwelling units on the sample had contact numbers. As of Q2: 2021, dwelling units without contact numbers maintained their status from Q1: 2021. Thus, residences that were out-of-scope in Q1: 2021 remained out-of-scope in Q2: 2021, whereas residences that were non-contacts in Q1: 2021 were non-contacts in Q2: 2021. During data collection, some contact numbers in the remaining Q2: 2021 sample with contact numbers turned out to be invalid, others were not answered, and some households in the sampled dwelling units indicated that they no longer lived in their previous dwellings. All of these were considered non-contacts during the weighting process and were adjusted accordingly.

RESULTS

The below table depicts the labour force of South Africa from April 2020 to June 2021. According to this report, the labour market interaction for 2021 does not encompass the entire economy. It takes into account the population aged 15 to 64 years in the labour force, that is, employed persons in formal and informal industries, in agricultural production, and private households, as well as the unemployed and the economically inactive in South Africa. The adult population increased by 145 000 or 0.4 percent from the first quarter (Q1) of 2021. An additional 578 000 workers (or 1.5%) aged 18-24 joined the workforce. Thus, the number of employed people decreased by 54 000 in Q1 2021, and the number of unemployed had increased by 584 000, resulting in an increase of 530 000 (2,4%) among people who were in the labour force. The number of discouraged job seekers grew (4.1%) between the two quarters, but the number of those not actively searching decreased (4.1%). As a result, 386 000 fewer people were unemployed between the two quarters (QLFS, 2021).

Table 3: South Africa's Decent Work indicators (Adapted from QLFS, 2021)

	Apr-Jun 2020 (Thousand)	**Jan-Mar 2021** (Thousand)	**Apr-Jun 2021** (Thousand)	
Population 15–64 yrs.	39 021	39 455	39 599	0,4%
Labour force	18 443	22 237	22 768	2,4
Employed	14 148	14 995	14 942	-0,4
formal sector (non-agricultural)	10 064	10 574	10 200	-3,5

Informal sector (non-agricultural)	2 280	2 502	2 686	7,4
Agriculture	799	792	862	8,7
Private households	1 005	1 127	1 194	6,0
Unemployed	4 295	7 242	7 826	8,1
Not economically active	20 578	17 218	16 832	-2,2
Discouraged work-seekers	2 471	3 131	3 317	5,9
Other (not economically active)	18 107	14 086	13 515	-4,1
Unemployment rate	23,3 %	32,6 %	34,4 %	
Employed/ population ratio absorption)	36,3 %	38,0 %	37,7 %	
Labour force participation rate	47,3 %	56,4 %	57,5 %	

SOURCE: STATISTICS SOUTH AFRICA – Quarterly Labour Force Survey (2021)

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The differences between individual labour market status categories were taken into account in order to better understand the observed large shifts between Q1: 2021 and Q2: 2021. The unemployment rate jumped from 32.6% to 34.4% between the second quarter and the third quarter. This is due to a large number of individuals moving from employable and inactive statuses to unemployed statuses during these quarters. Since the start of the Quarterly Labour Force Survey in 2008, this is the highest unemployment rate ever recorded. Due to these movements, the labour force participation rate also increased by 1.1 percentage points to 57.5% in Q2: 2021 as compared to Q1: 2021. The absorption rate fell by 0.3 percentage points to 37.7% in the second quarter of 2021 over the first quarter (QLFS, 2021).

In Q2: 2021, only 375 000 jobs were lost in the formal sector, while 184 000 were added in the informal sector, 69 000 in the agricultural sector, and 67 000 in private households. This is an indication that in 2021 the informal sector received more growth than the formal sector in South Africa. Overall, employment has grown by 793 000 jobs since the previous year. There were 3.5 million more unemployed people in the labour force, while there were 3.7 million more people who were not economically active (QLFS, 2021).

The population of South Africa has grown exponentially as depicted above, but the unemployment rate has risen by 8.1percent, and the employment rate has decreased by 0.4 percent. These numbers have been boosted by the discouragement of work-seekers which has risen 5.9 percent. This has automatically resulted in chronic poverty, one of the most intractable challenges for South Africa's workforce despite numerous government interventions. South Africa's Accelerated and Shared Growth Initiative (ASGISA) is one of many policies enacted by government to promote decent employment and also to promote economic growth. The policy framework's main objective is to create jobs. According to the plan, a million jobs would have been created by this programme in the five years to 2020. This combination of factors, coupled with the current stagnant economic growth in South Africa, makes it vitally important for funders, policy makers, and those working on projects aimed at employment creation to evaluate and invest in programmes that promote positive attitudes toward employment (Herrington, Kew, & Monitor, 2010) .

CONCLUDING REMARKS AND RECOMMENDATIONS

In summary, based on the results of the survey conducted, South Africans are not producing decent work at a high enough level to alleviate or eradicate poverty. The majority of South Africans were negatively impacted by historical racial inequalities when it came to finding decent employment. Socioeconomic development in South Africa is negatively affected by decent employment. Considered together, these have significant impact on South Africans' well-being. It can be deduced from the above analysis that there are a lot of intricacies within the South African labour market especially in the employment creation environment. The employment rate has dropped dramatically while the unemployment rate continues to rise, which was happening even before the COVID-19 pandemic. It is feared that if the experience of the pandemic is prolonged, it would continue to negatively affect the decent employment situation in South Africa and around the African continent and the world.. The analysis thus far points to the trend that the informal sector has grown nominally than the formal sector in terms of employment in South Africa. This trend does not, however demonstrate that decent employment opportunities have been created in the economy. One thing that the trend does show though is that large-scale unemployment remains a major socio-economic challenge to the country. This is more so as it has been established that unemployment or indecent employment breeds poverty in society.

Recommendations:

- Decent employment that is in sync with the ILO principles can help society to combat the challenge of poverty.

- A well-considered policy of government to empower the informal sector can help in the employment creation efforts of the country.
- There is a need to redouble efforts to ensure that the underpinning considerations that led to policy enactments to redress the historical imbalances and inequalities of the South African employment environment is concertedly pursued.
- The provision of decent employment should be vigorously pursued by government in order to eradicate poverty.

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