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Agricultural operations centers and data-driven management in the sugarcane and ethanol sector: fundamentals for the design of operational procedures and their impacts.

Agricultural operations centers and data-driven management in the sugarcane sector: foundations for the design of operational procedures and their impacts

Agricultural operations centers and data-based management in the sugar-energy sector: foundations for the design of operational procedures and their impacts

Rafael Dinardi Gonçalves
Agricultural Engineer from the State University of São Paulo (UNESP), Faculty of Agricultural and Veterinary Sciences, Jaboticabal campus. Specialist in Soil Management from the Luiz de Queiroz Higher School of Agriculture of the University of São Paulo (ESALQ/USP). MBA in Business Management from the Getulio Vargas Foundation (FGV).

SUMMARY

The mechanization of sugarcane harvesting and the diffusion of digital technologies in the field have increased the amount of data available on machinery, trucks, and agricultural operations, which has favored the creation of agricultural operations centers dedicated to real-time monitoring of work fronts. This article, developed through a narrative review of scientific, technical, and regulatory literature, discusses the fundamentals that should guide the design and use of operational procedures in these centers, as well as the expected impacts. The analysis articulates contributions from digital agriculture, agricultural machinery engineering, the logistics of the cutting, transshipment, and transport system, cognitive ergonomics, decision theory, and studies on work monitoring. The results indicate that the value of an operations center depends less on the quantity of data collected and more on the quality of the record, the definition of indicators consistent with the actual losses of the system, the clarity about who decides and within what timeframe, the handling of alarms, and the integration of analysis routines into the continuous improvement cycle. In conclusion, well-structured procedures can convert connectivity and telemetry into operational, security, and sustainability gains, provided they are accompanied by data governance, transparency with employees, and systematic evaluation of results.

Keywords: Digital agriculture; Telemetry; Sugarcane; Operations center; Operational procedures.

ABSTRACT

The mechanization of sugarcane harvesting and the spread of digital technologies in the field have increased the amount of data available on machines, trucks and agricultural operations, which has favored the creation of agricultural operations centers dedicated to real-time monitoring of field crews. This article, based on a narrative review of scientific, technical and regulatory literature, discusses the foundations that should guide the design and use of operational procedures in these centers, as well as their expected impacts. The analysis brings together contributions from digital agriculture, agricultural machinery engineering, harvest and transport logistics, cognitive ergonomics, decision theory and studies on workplace monitoring. The results indicate that the value of an operations center depends less on the amount of data collected and more on the quality of data recording, the definition of indicators consistent with the actual losses of the system, clarity about who decides and within what time frame, the handling of alarms and the integration of analysis routines into the continuous improvement cycle. It is concluded that well-structured procedures can convert connectivity and telemetry into operational, safety and sustainability gains, provided they are accompanied by data governance, transparency with workers and systematic evaluation of results.
Keywords: Digital agriculture; Telemetry; Sugarcane; Operations center; Operational procedures.

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1 INTRODUCTION

Sugarcane occupies a prominent place in Brazilian agriculture, and the National Company of
The Ministry of Supply estimated the 2025/2026 crop production at 673.2 million tons, the third largest.
largest in the historical series (CONAB, 2026). In the last two decades, the harvest has undergone a
accelerated mechanization process, driven by the gradual elimination of straw burning and
by the Agro-environmental Protocol signed in São Paulo in 2007 (Saiani; Perosa, 2016). The replacement
manual harvesting by teams composed of harvesters, tractors with transshipment equipment, and trucks.
It transformed harvesting into a highly complex logistical operation, in which small
Disruptions in one link propagate through the others and affect the industry's supply (Iannoni;
Morabito, 2006).

In parallel, the spread of onboard computers, positioning systems, telemetry and networks.
Communication in rural areas has increased the amount of information available about machinery and
operations. A survey conducted with 504 Brazilian producers indicated that 84% of them used
at least one digital technology and pointed to acquisition costs and connectivity as the
main challenges (Bolfe et al., 2020). In this context, operations centers have gained importance.
agricultural structures dedicated to monitoring the performance of crop fronts in near real-time.
work and support operational decisions. However, the literature on digital agriculture warns that...
Data availability does not automatically translate into better decisions, and issues of
Organization, governance, and power relations accompany the adoption of these technologies (Wolfert et al.
al., 2017; Klerkx; Jakku; Labarthe, 2019).

Given this, this article aims to discuss, in light of scientific, technical, and regulatory literature,
the fundamentals that should guide the design and use of operational procedures in centers of
agricultural operations in the sugarcane and energy sector, as well as the expected impacts of these procedures.
Regarding efficiency, safety, the environment, labor relations, and data governance. Search-
to offer a theoretical framework that helps managers and researchers address the operations center.
not as a monitoring room, but as part of a management system whose performance
It depends on the quality of the processes that support it.

2 METHODOLOGY

This is a qualitative and exploratory research study, conducted through a review.
The narrative of literature. The choice of this approach stems from the interdisciplinary nature of the subject, which
It involves digital agriculture, agricultural machinery engineering, logistics, cognitive ergonomics, and theory.

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of decision-making, quality management, and studies on work monitoring. Unlike
A systematic review, guided by a rigid protocol for searching and extracting data to answer a
With the question clearly defined, the narrative review allows for the articulation of references from different fields and the construction of...
a theoretical synthesis focused on an applied problem, which corresponds to the purpose of this study.
The searches were conducted in academic search engines and in journal portals and
publishers such as SciELO, ScienceDirect, MDPI, SpringerLink and Taylor & Francis, as well as repositories
Institutional programs of Brazilian universities and the Brazilian Agricultural Research Corporation.
The search and selection of works covered topics related to agriculture, in both Portuguese and English.
digital, telemetry, on-board computer, field efficiency, mechanized sugarcane harvesting
sugar, cutting, transshipment and transport logistics, situational awareness, information overload,
Alarm management and electronic work monitoring. Documents were also consulted.
technical and official guidelines, such as standards for managing agricultural machinery and designing control centers,
data from the Agricultural Census of the Brazilian Institute of Geography and Statistics and the legislation
Brazilian applicable.
The selection prioritized peer-reviewed articles and dissertations from graduate programs.
recognized, official documents and widely cited reference works in their fields, without
Strict restriction on the timeframe, since part of the fundamentals regarding decision-making, automation, and quality were...
formulated between the 1950s and 1990s and remains relevant today. The quantitative data were extracted.
from the original sources and used to illustrate the arguments, without any claim to generalization.
Statistics. The analysis was organized into six thematic axes, which structure the following sections. By
Since this is a review, the study does not empirically test hypotheses, and the propositions presented must...
to be understood as theoretical guidelines to be verified in field research.

3. From Precision Agriculture to the Agricultural Operations Center

The idea of managing agricultural operations based on data is not new. Bolfe et al. (2020) remind us that
The use of precision agriculture machinery and equipment since the 1990s has brought gains.
Productive and more efficient use of inputs, and that increasing connectivity in rural areas,
Combined with the integration of sensors, equipment, and cell phones, it paved the way for...
Concepts of Agriculture 4.0 or digital agriculture. Wolfert et al. (2017) distinguish agriculture from
precision, focused on spatial variability within the plot, of smart agriculture, which becomes
to base management tasks also on contextual data and events detected in real time.
An agricultural operations center can be understood as the organizational embodiment of this.
second stage, since it concentrates, in the same space, information generated by machines and vehicles

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and teams distributed throughout the territory.

Wolfert et al. (2017) describe smart agriculture as a cyber-physical management cycle, in which
Connected devices monitor the production system, the data is analyzed, and decisions are made.
They return to the field in the form of actions. The authors emphasize that large volumes of data are already...
Used to produce forecasts, support real-time operational decisions, and redesign processes.
business analysis. Kamilaris, Kartakoullis and Prenafeta-Boldú (2017), when reviewing 34 studies on business analysis
Based on large volumes of data in agriculture, they concluded that this practice was still in...
It was in its initial stage, and several barriers needed to be overcome. For the sugar and ethanol sector, this...
The reading suggests caution, as automated data collection is only the first link in a chain.
A chain that includes storage, processing, interpretation, decision-making, and verification of results.
Tzounis et al. (2017) analyzed the technologies associated with the Internet of Things in agriculture and
They showed that sensors, wireless networks, cloud computing, and radio frequency identification
They offer promising solutions for modernizing the sector, but still face challenges in their implementation.
diffusion in the sector. In sugarcane harvesting, these technologies appear mainly in computers.
on-board, which record the times of each operational state and the reasons for machine downtime.
(Silva, 2018), and in vehicle tracking systems. The value of this information, however,
It depends on them being transmitted regularly, integrated into a common database, and associated with...
Clear classification rules, without which the records of different machines and suppliers cannot be kept.
They can be compared.

The social science literature on agricultural digitalization expands this discussion. Klerkx, Jakku and
Labarthe (2019) identified five thematic groupings in studies on the subject, which include
The adoption and adaptation of technologies in properties, the effects of digitalization on identity.
and the work of farmers, knowledge and innovation systems, value chains and
issues of ethics and governance. Wolfert et al. (2017) also point out that large volumes of data
They tend to cause changes in the roles and power relations between the different actors in the chain.

These contributions indicate that deploying an operations center is not just a decision.
technological, but an organizational change that redistributes information, responsibilities and
Decision-making capacity across areas, hierarchical levels, and partners.
Zuboff (1988) offered a useful distinction for understanding this movement by differentiating the use of
Technology for automating tasks, its use for informing, that is, for making processes visible.
which previously remained opaque to the organization. According to the author, the informational potential of
Technology only becomes a reality when the organization develops the ability to interpret and act upon it.
new information. Applied to the agricultural operations center, this perspective suggests that the main
The gain is not in replacing manual entries with automatic records, but in...

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the ability to see, with regularity and precision, where time, fuel and
productive capacity. Operational procedures are the means by which this visibility is achieved.
transformed into learning and action, a theme that guides the following sections.

4. Connectivity and Data Quality as Basic Conditions

The operation of a real-time monitoring center presupposes connectivity in the field.
A condition that, according to the latest Agricultural Census, was far from being widespread in rural areas.
Brazilian. According to the 2017 Agricultural Census, of the 5,073,324 agricultural establishments in Brazil...
In the country, 1,430,156 producers declared having internet access, with approximately 659,000 using broadband.
909,000 via mobile internet, while in 2006 only 75,000 establishments had access (IBGE,
(2019). Although growth has been significant, the numbers indicate that most of the
establishments remained disconnected at that time. Bolfe et al. (2020) confirm this.
limitations in identifying connectivity, alongside the costs of machines, equipment, and software.
Among the main challenges perceived by producers for the adoption of digital technologies.
For large-scale operations, such as sugarcane harvesting fronts, connectivity needs to be...
treated as production infrastructure and not as an ancillary service. Tzounis et al. (2017), to
Reviewing wireless communication technologies used in agriculture shows that the choice
Among these aspects are trade-offs between range, transmission rate, and energy consumption.
especially relevant in large areas far from urban centers. From the point of view of
procedures, this implies predicting how the system behaves when communication fails. It proposes-
if, in this study, the procedures define the local storage of records in
equipment, subsequent synchronization with the central base, signaling of transmission gaps
and alternative forms of communication between the center and the front lines, so that signal loss does not
which could lead to a loss of information or a decision based on incomplete data.
Data quality is the second basic condition. Kamilaris, Kartakoullis and Prenafeta-Boldú (2017)
Among the dimensions of large volumes of data, they highlight veracity, which refers to accuracy and
Regarding the credibility of the information. In onboard computers, a large part of the records are generated
Automatically, things like engine hours and position are tracked, but another part depends on the operator, such as...
indication of the reason for each stop. When the operator chooses a generic category, it omits
pointing out the stop or recording an incorrect reason, the data loses analytical value. Silva (2018), when
analyzing onboard computer records from eight harvesters, he worked with thousands of hours of
Stops are classified by cause, which presupposes a consistent classification of records. A
Standardization of the list of reasons, operator training, and periodic auditing of

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Notes therefore become essential components of the procedure.

Wolfert et al. (2017) point to data governance, which includes ownership, privacy and security, as one of the central issues to be addressed in smart agriculture, alongside Defining business models for information sharing. In the sugar and ethanol sector, This issue takes on concrete dimensions, since the harvesting fronts bring together equipment for different manufacturers, transport service providers and sugarcane suppliers, each with their own systems. Defining who owns each piece of data, who can access it, and for what purposes. The objectives must be defined before the integration of the bases. Without this prior agreement, the operations center... It can operate with partial information or generate conflicts with partners who do not recognize the legitimacy of the use of your data.

A third condition concerns the integration between systems. Lejars, Le Gal and Auzoux (2008) They argue that the decisions made at different levels of the sugarcane supply chain do not They can no longer be considered independently, as they affect the overall profitability, and They proposed a simulation-based decision support approach to facilitate negotiation. between producers and mills. This articulation presupposes that field, transport and data Reception practices in the industry can be related to each other, for example, by the common identification of plots, fronts, trips and loads. It is proposed that the design of the operations center begin with defining this common data model, because it is what allows us to answer questions that They go through different stages, such as the effect of a harvest stoppage on the truck queue in scale or about hourly grinding.

5. Operational Efficiency and Lost Time in the Cutting System. TRANSFER AND TRANSPORT

Agricultural machinery engineering provides the basic concepts for interpreting the generated data. in the field. The agricultural machinery management standard of the American Society of Agricultural and Biological engineers define field efficiency as the ratio between effective capacity and... theoretical capacity of a machine and associates the differences between the two with factors such as the ability of operator, area format, work pattern, maneuvers, refueling and unloading (ASABE, 2006). Santos et al. (2014) evaluated, through computational modeling, the impact of efficiency of field study on the operational capacity and production cost of the harvester and transshipment system in mechanized sugarcane harvesting. These concepts allow for the translation of computer records into On board, comparable indicators are used, provided that the times are classified in a consistent manner.

In sugarcane harvesting, the machine does not operate in isolation. The harvester depends on the transshipment vehicle to...

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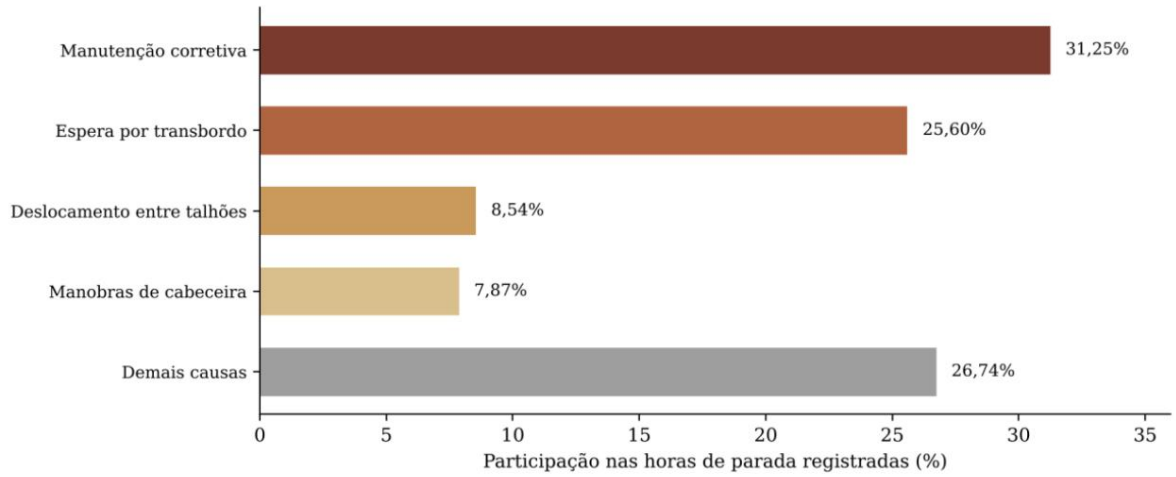
To unload the chopped sugarcane, the transshipment depends on the truck to transfer the load, and the truck
It depends on traffic conditions and reception in the industry. Iannoni and Morabito (2006) analyzed,
Through discrete simulation, the sugarcane receiving system of a mill was analyzed and shown that the
performance measures, such as average truck waiting time and unloading rate,
depend on the configuration and operating policies adopted. The consequence for the center of
The operation requires that the indicators for each piece of equipment be read together, since one
A stopped harvester may reflect a lack of transshipment, and an idle transshipment may reflect a problem in...
combine harvester or truck.

Silva (2018) analyzed onboard computer data from eight harvesters, collected between April and
August 2015, which totaled 29,346.3 hours, and identified that corrective maintenance responded
31.25% of recorded downtime hours were due to waiting for transfers, 25.60% to the displacement of
Machinery between plots accounted for 8.54%, and maneuvers at the end of the line for 7.87%. In the same study, the
The mechanical availability of the harvesters was 74.6%, the operational efficiency was 44.4%, and...
overall efficiency of 27.9%. Figure 1 summarizes the distribution of downtime causes and shows that
More than half of the downtime was concentrated in just two causes, one related to maintenance and
another aspect is the logistics of supporting the harvest.

Figure 1 – Distribution of downtime hours for eight sugarcane harvesters by cause, recorded by on-board computer between April and August 2015



Source: Prepared by the author based on Silva (2018). Note: the category "other causes" was obtained by difference in relation to the total hours of downtime recorded.

Reading this data helps guide the design of procedures. When most of the losses
If the focus is on a few causes, it is reasonable to prioritize analysis and action on those causes, instead
to disperse efforts across all indicators at the same time. Nakajima (1988), when structuring the

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total productive maintenance, proposed overall equipment efficiency as an indicator that combines availability, performance, and quality, and organized the losses into categories that allow Identify where productive capacity is consumed. Adapted to sugarcane harvesting, this logic suggests that the operations center separately track losses due to maintenance, logistical delays, by displacement and by maneuver, since each requires different responsible parties and responses. Waiting for transfers, the second leading cause in Silva's study (2018), clearly illustrates the role of the center. of operations as system coordinator. This type of loss does not result from combine harvester failure, but due to the imbalance between the harvesting capacity and the capacity to remove the sugarcane from the plot. Iannoni Morabito (2006) showed that alternative operating configurations and policies alter the performance of the reception system, and Lejars, Le Gal and Auzoux (2008) highlighted that decisions Decisions made at different levels of the supply chain influence the overall outcome.

It is therefore proposed that the center's procedures include rules for the redistribution of transfers and trucks between work fronts, with activation criteria based on accumulated waiting time, and that these decisions be recorded for later evaluation of their effectiveness.

6. DECISION-MAKING, SITUATIONAL AWARENESS, AND THE ROLE OF THE OPERATOR

An operations center is, first and foremost, a decision-making environment. Simon (1955) showed that real decision-makers operate under bounded rationality, with incomplete information and limited time. and finite cognitive capacity, and that, under these conditions, they tend to seek satisfactory solutions instead of excellent quality. Klein (1998), when studying professionals who make decisions under time pressure, such as firefighters. and military personnel, he noted that quick and effective decisions often rely on the recognition of Patterns built through experience, not through exhaustive comparison of alternatives. These two References indicate that the design of the operations center should reduce the search and response load. interpretation imposed on operators, offering information already organized around decisions. that they need to take.

Endsley (1995) defined situational awareness at three levels, which correspond to the perception of elements of the environment, to understanding their meaning and projecting their future state. In a A center that monitors dozens of harvesters and trucks, the screen that shows the position and status of Each piece of equipment only addresses the first level. Understanding requires that the operator knows, therefore For example, if a harvester is stopped due to scheduled maintenance, awaiting transshipment, or with... failure, and the projection requires estimating the effect of this stoppage on the sugarcane delivery target to the industry in The following hours. It is proposed that the interfaces and procedures be designed based on these. questions, so that the information presented supports understanding and anticipation, and not just

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the observation.

Information overload is a real risk in these environments. Eppler and Mengis (2004), in reviewing
The literature on information overload in different fields has systematized its causes and effects.
and countermeasures and showed that, beyond a certain point, the increase in the amount of information
The availability of resources can compromise the quality of decisions. The ISO 11064 standard, dedicated to design...
The ergonomic design of control centers establishes principles that include user-centricity,
Analysis of tasks and consideration of human capabilities and limitations in the design of rooms and workstations.
of work and interfaces (ISO, 2000). In the agricultural operations center, these guidelines suggest
limit the number of indicators displayed simultaneously, prioritize information by urgency and
Relevance and avoid screens that simply reproduce all available data.

Alarm management deserves specific treatment. The ANSI/ISA-18.2 standard, developed for the
The process industry establishes a life cycle for alarm systems that includes philosophy,
identification, rationalization, design, implementation, operation, maintenance, monitoring and
evaluation, based on the principle that each alarm should require a defined response from the operator.
(ISA, 2016). Transposed to the field, this logic implies that warnings such as speeding,
Prolonged stops, route deviations, or abnormal fuel consumption should only occur if there is a reason.
An associated action, a responsible party, and a response deadline. The standard itself provides for monitoring.
continuous monitoring of the alarm system's performance, including nuisance alarms and periods of
There is an excess of alarms, which reinforces the need to periodically review the relevance of each alert.
set up in the center.

Parasuraman, Sheridan, and Wickens (2000) proposed that automation can operate in four functions,
The acquisition of information, the analysis of information, the selection of decisions, and the implementation of actions.
each with distinct levels of autonomy. Bainbridge (1983) warned that the more
An automated system, however, requires a human operator to handle the difficult tasks and less of the work.
Opportunities require maintaining your skills. At the center of agricultural operations, the collection and...
Data processing can be largely automated, while decisions such as reallocation
Equipment between work fronts, interrupting an operation due to risk, or activating field maintenance.
It involves judgment. Clearly defining what is the responsibility of the systems and what is the responsibility of individuals, in each case.
This step avoids both over-reliance on automation and underutilization of tools.
available.

7. DESIGN OF MANAGEMENT PROCEDURES AND ROUTINES

Operational procedures are the way an organization transforms knowledge into

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repeatable practice. Ohno (1988), in describing the Toyota production system, highlighted the work standardized as an element of production organization, with the definition of the sequence of tasks, of the cycle time and the inventory required for each operation. In the tradition of lean production, this Standardization is treated as a reference point from which deviations are identified and improvements are made. They are evaluated. In the agricultural operations center, this idea applies both to the work of the operators. from the classroom to the interactions with the field. It is proposed that the procedure describe, for each type of relevant event, the signal that identifies it, the person responsible for the first response, the information to be Once confirmed, the possible actions, the expected timeframe, and the method of registration are outlined, so that the response does not... It depends exclusively on the individual experience of whoever is on the shift.

Standardization, however, is not an end in itself, but the starting point of a cycle of... learning. Deming (1986) presented the Shewhart cycle, of plan, do, check and act, as a method of continuous improvement, in which the results of each intervention are evaluated and incorporated into the following standard. For the operations center, this means that the routines are not... They are limited to monitoring indicators during the shift, but include structured moments of analysis. A hierarchy of routines is proposed that combines continuous monitoring during operation, Brief handover meetings focusing on incidents and pending issues, weekly reviews of main causes of loss and periodic reviews of the procedures themselves, with the participation of Field, maintenance, and logistics leadership.

The choice of indicators influences the organization's behavior. Kaplan and Norton (1992) They argued that performance measurement systems strongly influence the behavior of managers and teams proposed combining financial and operational indicators into a set balanced. In the context of the operations center, this warning is especially relevant because Isolated indicators can induce local optimizations to the detriment of the system. A rigid target of The number of tons harvested per combine harvester, for example, can stimulate an increase in speed as a reflex. regarding losses, impurities, and wear, while a purely fuel consumption target may to discourage unnecessary travel. It is proposed that the indicators be defined jointly, cover efficiency, quality, safety, and cost, and are explicitly related to main causes of loss identified in the data.

Acceptance of procedures by the teams is another determinant of their success. Davis (1989) showed that perceived usefulness and perceived ease of use are associated with acceptance of Information technologies by users, and Rogers (2003) described the diffusion of innovations as a social process influenced by relative advantage, by compatibility with existing practices, due to its complexity, the possibility of experimentation, and the visibility of the results. Bolfe et al. (2020) recorded that 95% of the producers interviewed would like to learn more about new

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technologies. These contributions suggest that the deployment of an operations center should include
Training of machine operators and team leaders, regular feedback of information to the teams.
Field experience and user participation in reviewing routines and downtime reason lists.
Finally, the design of the procedures needs to consider the relationship between the center and the leadership of
field. Klerkx, Jakku and Labarthe (2019) point out, among the themes of literature, the effects of
Digitalization of the work and skills of the people involved. If the center starts to see in
In real time, information that previously only the frontline leader knew, there is a risk of overlapping commands.
and the loss of autonomy for those in the field. It is proposed that the procedures define with
Clarify the roles of each instance, reserving for the center the function of observing the system as a whole.
In short, identify deviations and coordinate resources between fronts, and the decision on the field leadership is left to the field leadership.
local implementation, with defined communication channels and a record of decisions made by both parties.
parts.

8 Operational, Safety, Environmental, Labor and... Impacts
GOVERNANCE

The operational and economic impacts are those most directly associated with operations centers.
The reviewed literature discusses the effect of field efficiency on operational capacity and cost.
mechanized harvesting (Santos et al., 2014) indicates that a significant portion of the time of
Harvesters can be consumed by downtime related to maintenance and support logistics (Silva, 2018).
By making these losses visible and organizing standardized responses, the center creates conditions for
reduce them. The magnitude of this effect, however, depends on the starting point of each operation, on
The quality of the data and the effectiveness of the actions taken are crucial, which is why the expected gains should...
to be estimated from proprietary baselines and not from generic average values.
In the field of security, speed, route, and driving time monitoring offers
Instruments for monitoring risky behaviors and compliance with work schedule rules. A
Law No. 13.103/2015 regulates the working hours and driving time of professional drivers and allows that
the journey is controlled and recorded by electronic systems and means installed in the vehicles,
Employer criteria (Brazil, 2015), which aligns travel records with obligations.
labor issues in sugarcane transportation. The same data can allow the identification of sections of
road with a higher frequency of risk events and the guidance for infrastructure interventions or
of signage. For these benefits to materialize, the procedures must define how the
Safety alerts are handled, who is responsible for approaching the driver or operator?
and how incidents feed into training programs, preventing monitoring

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is reduced to a punitive mechanism.

The environmental impacts stem primarily from the more rational use of machinery and fuel.
Reducing idle time with the engine running, unnecessary travel, and waiting time tends to...
to reduce fuel consumption per ton harvested and transported and, consequently, the
associated emissions. Wolfert et al. (2017) note that data applications in agriculture
Intelligent systems reach the entire supply chain, which opens up the possibility of using the records.
from the field, also for emissions accounting and for traceability that may be required.
through certifications and buyers. These benefits, however, can only be proven if the
The operations center should maintain reliable historical records of consumption, hours worked, and...
The volume transported reinforces the importance of data quality discussed in section 4.

Electronic monitoring also has effects on labor relations. Ball (2010) shows
that organizations monitor employees primarily to protect their assets, but that
The nature and intensity of the surveillance reveal how the company views its workers and
They have consequences for well-being, culture, productivity, creativity, and motivation.
The author notes that location tracking is among the forms of monitoring in
expansion. In the context of operations centers, this warning indicates that transparency about what is
monitored, for what purpose and in what way is the data used in individual assessments?
A condition for technology to be perceived as a support for work, and not just as a means of control.

Data governance completes the picture of impacts. The General Law on the Protection of Personal Data
establishes principles such as purpose, suitability, necessity, transparency and safety in
processing of personal data, which includes information related to operators and drivers.
Identifiable factors, such as location, journey, and driving behavior (Brazil, 2018). Wolfert et al.
(2017) highlight that ownership, privacy and data security are among the central issues.
of smart agriculture, and Klerkx, Jakku and Labarthe (2019) include ethics and governance among the
Topics from the literature on agricultural digitization. It is proposed that the center's procedures define
legal bases, retention periods, access profiles and rules for sharing with providers of
service and suppliers, treating governance as part of the operational design and not as a separate step.
posterior.

CONCLUSION

The mechanization of sugarcane harvesting transformed the agricultural operation into a system.
interdependent logistics, in which harvesters, transshipment equipment, and trucks need to operate in a way that...
coordinated efforts to ensure the supply of the industry. The spread of onboard computers,

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Telemetry and communication networks made it possible to monitor this system in near real-time, and
Agricultural operations centers emerged as an organizational response to this possibility.
The review suggests that the value of these centers does not stem from the technology itself, but from the capacity of
The organization's role in interpreting and acting upon the information it makes visible. The distinction between
Automating and informing helps to understand this point, as the main benefit lies in seeing with
regularity where time, fuel and productive capacity are lost, and in transforming that
Visibility in decision-making and learning. Without this capability, the accumulated data tends to...
If they remain underutilized, the center risks becoming merely an observation space.
Connectivity, data quality, and system integration are fundamental requirements. The data
Data from the Agricultural Census and research with producers show that connectivity is still a
This is a challenge in the Brazilian rural environment, and the procedures need to anticipate the behavior of the system.
When communication fails. Standardization of downtime reasons, operator training.
Auditing the records is essential to ensure they have analytical value.
The concepts of field efficiency and overall equipment efficiency offer a language
common for interpreting data from onboard computers. Study data with harvesters.
Studies indicate that few causes, such as corrective maintenance and waiting for transshipment, can
This concentrates a large portion of downtime, which suggests prioritizing analysis and action on these issues.
Causes and reading the indicators of each piece of equipment in conjunction with the other links in the system.
The operations center is also a decision-making environment subject to human limitations.
bounded rationality, the importance of pattern recognition, levels of consciousness
The situational context and the risks of information overload indicate that interfaces and procedures should...
to be designed based on the decisions that operators need to make. Alarm management, with
Each alert, associated with an action, a responsible party, and a deadline, is an essential part of this design.
Operational procedures should combine standardization and continuous learning. The definition
A clear system of signs, responsibilities, actions, and records for each type of event, linked to analysis routines.
across different time horizons and balanced indicators, it allows the center to cease being...
An observation room can then function as a tool for improving the system as a whole.
without removing the autonomy of field leadership over local implementation.
The impacts of well-structured procedures reach different dimensions. They can contribute
to reduce operational losses, support transportation safety, and ensure compliance with regulations.
journey, reduce fuel consumption and associated emissions, and produce useful records for
Traceability and certification. At the same time, they require attention to the effects of monitoring on
workers and the processing of personal data are issues that need to be incorporated into the design.
Operational from the start.

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As this is a narrative review, this study has limitations, including the absence of verification.
empirical analysis of the propositions and the use of studies conducted in specific contexts, whose results
These findings cannot be generalized to all operations. Future research is recommended to evaluate...
in different plants and regions, the relationship between the maturity of the procedures of the centers of
operations and indicators of efficiency, safety and consumption, as well as the perception of
workers on monitoring, in order to consolidate their own evidence base for the
sector.

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