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READINESS FOR THE TRANSFORMATION OF SUSTAINABLE PEOPLE'S COCOA AGROINDUSTRY BASED ON APPROPRIATE TECHNOLOGY AND OCCUPATIONAL SAFETY: A QUALITATIVE CASE STUDY

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ABSTRACT
The people's cocoa agroindustry has strategic potential in increasing the added value of local commodities and supporting the development of region-based chocolate products. However, the transformation process towards a sustainable agroindustry still faces various challenges, such as the limitations of processing technology, the implementation of occupational safety and health (OSH), work systems that are not yet ergonomic, and the limited capacity of business actors to adopt innovations in accordance with local conditions. This study aims to explore the readiness of the transformation of the smallholder cocoa agroindustry towards a sustainable production system through the application of appropriate technology and improvement of occupational safety practices in the small and medium cocoa processing industry in Kulon Progo Regency. This study uses a qualitative approach with a case study design on the small-scale cocoa agroindustry in Kulon Progo Regency. Data collection was carried out through field observations, in-depth interviews with eight informants, and documentation of farmer groups, cocoa processing industry players, and workers involved in the production process. Data was analyzed using thematic analysis methods to identify existing conditions, technological needs, the application of occupational safety, as well as supporting and inhibiting factors in the agroindustrial transformation process. The results of the study show that the smallholder cocoa agroindustry has great development potential, but still faces obstacles in the form of limited production equipment, the lack of a standardized work system, and the low integration of occupational safety aspects in production activities. Transformation readiness is influenced by several main factors, namely the suitability of technology with user needs, ease of operation, understanding of the importance of occupational safety, and support for collaboration between farmers, industry, and educational institutions. The transformation of the sustainable smallholder cocoa agroindustry requires an integrated approach that combines the application of appropriate technology, strengthening the culture of occupational safety, and the development of collaboration between stakeholders. This study provides a preliminary overview of the conditions and readiness factors needed to build a safer, more efficient, and sustainable smallholder cocoa agroindustry at the local level.

Keywords: agroindustry; appropriate technology; cocoa; occupational safety and health; qualitative; small industry

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INTRODUCTION

Cocoa is one of the plantation commodities that has great potential in supporting the development of agro-industry and increasing the added value of agricultural products (de Boer et al., 2019). The transformation of cocoa from a primary commodity to a processed product such as chocolate provides opportunities to increase income for farmers and strengthen the economy of local communities (de Boer et al., 2019; Prazeres et al., 2022). However, the development of smallholder cocoa agroindustry still faces various challenges, especially at the small and medium industry (SMI) level, which include limited processing technology, low production process efficiency, limited

human resources, and the implementation of the occupational safety and health system (OSH) (de Boer et al., 2019; Prazeres et al., 2022).

Kulon Progo Regency is one of the areas that has the potential for the development of smallholder cocoa with the support of farmer groups and the local chocolate processing industry (Bachtiar, 2020). However, the cocoa downstream process at the local level still needs strengthening, especially in terms of technological readiness and work systems that are able to support business sustainability (Anoraga et al., 2020; Bachtiar, 2020). Some agro-industry players still use simple equipment with a limited level of mechanization, thus affecting product quality consistency, production capacity, process efficiency, and working conditions of workers (Andriani et al., 2021; Anoraga et al., 2020; Bachtiar, 2020). In addition, the aspect of occupational safety is often not an integral part of the management of the production process, so it has the potential to pose a risk of work accidents, fatigue, and health problems due to non-ergonomic work activities (Andriani et al., 2021; Ansori et al., 2021; Tremblay & Badri, 2018).

The application of appropriate technology is one of the approaches that can support the transformation of the people's cocoa agroindustry because the technology can be adjusted to the needs, capacity, and socio-economic conditions of the user community (Mottaleb, 2018; Adomaa Screwdriver et al., 2022). However, the success of technology adoption does not only depend on the technical aspects of the equipment, but is also influenced by the readiness of the user, the suitability of the technology with production needs, ease of operation, as well as institutional support and collaboration between stakeholders (Mottaleb, 2018; Adomaa Screwdriver et al., 2022; Takahashi et al., 2020). Therefore, understanding the existing conditions and factors that affect transformation readiness is an important aspect before the development of more sustainable technology and production systems (Hidayati et al., 2023; Mottaleb, 2018; Obeng Adomaa et al., 2022).

Previous research on cocoa agroindustry has focused on improving product quality, optimizing processing processes, marketing strategies, and developing the cocoa value chain (Barrientos et al., 2019; Lenou Nkouedjo et al., 2020; Prazeres et al., 2022). However, studies that specifically explore the readiness for the transformation of the smallholder cocoa agroindustry by integrating aspects of appropriate technology and occupational safety in the context of small and medium industries are still relatively limited (Ansori et al., 2021; Obeng Adomaa et al., 2022; Prazeres et al., 2022; Tremblay & Badri, 2018). A qualitative approach is needed to understand more deeply the experiences, perceptions, needs, and obstacles faced by agroindustry actors in the process towards a safer and more sustainable production system (Obeng Adomaa et al., 2022; Prazeres et al., 2022). This research aims to explore the readiness for the transformation of sustainable smallholder cocoa agro-industry through the application of appropriate technology and improving work safety practices in the small and medium cocoa processing industry in Kulon Progo Regency. The results of the research are expected to provide an understanding of the actual condition of the smallholder cocoa agroindustry and become the basis for the preparation of technology development strategies and work systems that are safer, more efficient, and in accordance with the needs of the local community.

METHOD

This study uses a qualitative approach with a case study design to deeply understand the readiness for the transformation of the people's cocoa agroindustry towards a sustainable production system through the application of appropriate technology and occupational safety. The case study was chosen because the research focuses on exploring the real conditions, experiences, and perspectives of agroindustry actors in the local context in Kulon Progo Regency. The location of the research was carried out in the people's cocoa agroindustry unit involving farmer groups and small and medium industries processing local chocolate in Kulon Progo Regency, Special Region of Yogyakarta. The selection of the location was carried out purposively by considering the

involvement of business actors in the cocoa production process, chocolate product processing activities, and the potential for the development of appropriate technology.

The research informants were selected using a purposive sampling technique involving involving eight informants comprising industrial owners or managers, production workers, members of cocoa farmer groups, and related parties who have experience and understanding of the production process and development of the cocoa agroindustry. Data collection was carried out through direct observation of production activities, in-depth interviews, and documentation of work process conditions, equipment use, and the implementation of occupational safety. The data obtained was analyzed using a thematic analysis method through several stages, namely transcription of interview data, coding process, identification of main themes, grouping of findings, and interpretation of data. The analysis focused on four main aspects, namely the existing condition of the cocoa agro-industry production system, the need and readiness for the application of appropriate technology, occupational safety and health practices, and supporting and inhibiting factors for sustainable agroindustry transformation.

The validity of the data is maintained through triangulation of sources and methods by comparing information from various informants and integrating the results of interviews, observations, and field documentation. This approach is used to gain a comprehensive understanding of the readiness for the transformation of the smallholder cocoa agro-industry and formulate the need for the development of a safer, more efficient, and sustainable production system. This study received ethical approval from the Health Research Ethics Committee, Faculty of Nursing and Health Sciences, Universitas Muhammadiyah Semarang, under ethical clearance certificate number 005/KE/05/2026. All participants received information regarding the study and provided informed consent before data collection. Participant confidentiality and anonymity were maintained throughout the research and publication processes.

RESULT

Characteristics of Informants and Data Collection Process

This research involves several groups of informants who have direct or indirect involvement in the people's cocoa agroindustry system in Kulon Progo Regency. The selection of informants was carried out purposively to obtain diverse perspectives on production conditions, the application of occupational safety, technological needs, and the readiness for transformation towards sustainable agroindustry. The total number of informants in this study is 8 people, consisting of local chocolate processing industry managers, production workers, cocoa farmer groups as raw material providers, and supporters who understand aspects of technology and industrial development.

Table 1.
Characteristics of Research Informants

Informant Code	Features	Quantity	Role in the Agroindustry System	Extraceted Data
I1	Local chocolate industry manager	1	Decision-makers and business process managers	Business strategy, production conditions, technology needs, development barriers
I2	Production operators	3	Cocoa processing activities	Work activities, work risks, use of tools, need to improve the work system
I3	Cocoa Farmers Group	2	Raw material providers and post-harvest actors	Upstream conditions of cocoa, production constraints, relationship with industry
I4	Companion partners	1	Business development support	Collaboration, the need for capacity building
I5	Academics/experts	1	Supporting technology and OSH aspects	Need for technology design and work safety system

Thematic Analysis Results

Analysis of interview data, field observations, and documentation produced four main themes that illustrate the readiness for the transformation of sustainable cocoa agro-industry. The results of the coding process are shown in Table 2, the four themes are:

1. Existing conditions and challenges of the people's cocoa agro-industry production system
2. Gaps in the implementation of occupational safety and health in the production process
3. Readiness to adopt appropriate technology based on user needs
4. Supporting ecosystems and barriers to sustainable agro-industrial transformation

Tablel 2.
Research Thematic Analysis Matrix

Initial Code	Category	Subtopic	Main Theme
Equipment is still simple	Limitations of technology	Limited production capacity	Production system conditions
Labour-dependent production	Human dependency	Limitations of the production system	Production system conditions
No written SOP	Low standardization	Production management	Production system conditions
PeWork Learning from Seniors	Informal knowledge transfer	HR Management	Production system conditions
Dangers are known from experience	Informal risk awareness	Hazard identification	Application of OSH
PPE has not been consistent	Risk control is not optimal	Safety culture	Application of OSH
Inappropriate work posture	Risk ergonomics	Working environment conditions	Application of OSH
Production is a top priority	Productivity conflict-OSH	Work culture	Application of OSH
Requires simple tools to use	Technology acceptance	Technology suitability	Technology adoption
Cost is a consideration	Economic feasibility	Barriers to adoption	Technology adoption
Need training on the use of tools	HR Readiness	Technology implementation	Technology adoption
Need for academic support	External collaboration	Institutional strengthening	Agro-industrial transformation
Capital limitations	Financial barriers	Business capacity	Agro-industrial transformation

Theme 1: Existing Conditions and Challenges of the People's Cocoa Agroindustry Production System

Production Systems Still Rely on Conventional Equipment

The results of observations show that the production process of folk cocoa in Kulon Progo still uses a combination of manual methods and simple equipment. Although the available equipment has been able to support the basic production process, the system has not been fully able to answer the needs of increasing capacity and consistency of product quality. In the current conditions, production capabilities are greatly influenced by the experience of operators and the availability of labor. One of the industry managers said:

"Untuk produksi sehari-hari alat yang ada masih bisa digunakan. Tetapi ketika ada peningkatan pesanan, kami mengalami kendala karena prosesnya membutuhkan waktu lebih lama.". "For daily production the existing tools can still be used. But when there is an increase in orders, we have problems because the process takes longer." (I1 – Industry managers)

The statement shows that the limitations of technology are one of the limiting factors in business development. The technology used has not fully functioned as a productivity lever, but is still a tool for the production process.

Production Knowledge Is Still Tacit Knowledge

In addition to the technological aspect, the study found that most of the production knowledge is still stored in the experience of senior workers. New workers acquire skills through a process of direct observation and work practice, rather than through standard procedure documents. One worker said:

"Biasanya pekerja baru mengikuti pekerja lama. Kalau ada masalah di proses, biasanya ditanyakan kepada yang sudah lebih lama bekerja." . "Usually, new workers follow old workers. If there are problems in the process, they usually ask those who have been working longer." (I2 – Production operators)

These conditions show that the production system still has a high dependence on certain individuals. From an industrial sustainability perspective, this condition is challenging because the loss of experienced labor can lead to the loss of important operational knowledge.

Production Process Standardization is not Optimal

The results of the study show that the standardization of the production process is still limited. Some process parameters are still determined based on the experience of workers. For example, decisions about certain process conditions are still made based on visual observations and operator experience. The informant said:

"Selama ini pengalaman pekerja menjadi patokan utama untuk menentukan apakah proses sudah sesuai atau belum." "So far, the experience of workers has been the main benchmark to determine whether the process is appropriate or not." (I1 – Industry managers)

These findings show the need for a more documented production system through more systematic SOPs, process parameters, and quality control.

Theme 2: Gaps in the Implementation of Occupational Safety and Health

Awareness of Occupational Hazards Exists, but is not yet Systematic

The results of the study show that workers actually have an understanding of potential occupational hazards. However, this understanding still comes from personal experience and has not yet become part of the risk management system. Workers submit:

"Kami sudah tahu bagian yang berbahaya, terutama saat menggunakan alat panas atau mesin tertentu. Tetapi belum pernah dilakukan identifikasi risiko secara formal." "We already know the dangerous parts, especially when using a heat tool or a specific machine. But there has never been a formal identification of the risks." (I3 – Production operators)

This shows that there is a gap between worker awareness and the implementation of the OSH system.

Safety Culture Is Still Reactive

Other findings suggest that occupational safety often gets attention after problems arise.

"Biasanya kalau belum ada kejadian dianggap masih aman. Perhatian terhadap keselamatan meningkat kalau sudah ada masalah." "Usually, if there has been no incident, it is considered safe. Attention to safety increases if there is already a problem." (I1 – Industry managers)

This condition shows that the safety culture is still in a reactive stage. Sustainable agro-industry transformation requires a change towards a preventive culture through hazard identification, risk evaluation, technical control, safe work SOPs, and worker training.

Theme 3: Readiness for Appropriate Technology Adoption

Technology Suitability Is the Main Factor in Acceptance

The results of the interviews show that business actors have a positive attitude towards technological innovation, but technology must be in accordance with the real conditions of users.

"Kami membutuhkan alat yang membantu pekerjaan, tetapi harus mudah digunakan karena operatornya bukan teknisi khusus. "We need tools that help with the job, but it has to be easy to use because the operators are not specialized technicians. (I1 – Industry managers)

This shows that the success of technology is determined not only by the technical capabilities of the tool, but also by the *user-fit*.

Cost and Maintenance Factors Determine Technology Sustainability
In addition to ease of use, investment and maintenance costs are the main considerations.
"*Kalau alat bagus tetapi sulit dirawat atau biaya perbaikannya tinggi, kami juga akan kesulitan."* "*If the equipment is good but difficult to maintain or the repair costs are high, we will also have a hard time." (I2 – Business owners)*
Thus, appropriate technology must meet the principles of simplicity, economical, easy to maintain, safe to use, and according to production needs.

Theme 4: Supporting Factors and Obstacles to Agroindustry Transformation
Collaboration Support as a Driver of Transformation
Collaboration between business actors, farmer groups, academics, and the government is an important factor. The informant conveyed:
"Kami memiliki keinginan berkembang, tetapi membutuhkan pendampingan agar tidak salah memilih teknologi." "We have a desire to grow, but we need assistance so that we don't choose the wrong technology." (I1 – Industry managers)

Barriers to Transformation
Some of the main obstacles found are technological barriers, such as limited access to tools, and limited understanding of technology. Human resource barriers such as limited technical skills and lack of continuous training. Management barriers such as SOPs are not yet available and process documentation is not optimal.

DISCUSSION

The results of the study show that the readiness for the transformation of the smallholder cocoa agroindustry in Kulon Progo Regency is not only determined by the availability of technology, but is a condition formed from the interaction between technology, people, work systems, occupational safety, and institutional capacity. Findings regarding the limitations of production equipment, dependence on operator experience, suboptimal process standardization, and the need for assistance show that agroindustrial transformation needs to be understood as a comprehensive system change. Thus, the success of transformation is not only measured by the ability of an equipment to function technically, but also by the ability of users to receive, operate, maintain, and integrate the technology into daily production activities (El Bilali, 2020; Ruzzante et al., 2021).

Findings on the limitations of production technology also show that the need of agro-industry actors is not solely for more sophisticated technology, but for technology that is suitable for the real conditions of users. The development of technology for rural communities with limited economic resources and knowledge needs to consider the suitability of technology with the local context (Philips et al., 2014). Studies on cocoa dryers in Nias show that the right technology needs to consider local resources, user capabilities, market needs, economic aspects, and stakeholder involvement in the design process (Sianipar, 2022). The findings strengthen the results of this study that the concept of appropriate technology in the smallholder cocoa agro-industry should be interpreted as a technology that is right to function, right to use, right conditions, right cost, and can be maintained sustainably.

The dependence of the production process on the experience of workers is another important finding. Knowledge about the operation of tools, determining process conditions, identifying production problems, and making decisions during the process is still widely obtained through direct experience. These conditions indicate the existence of *strong tacit knowledge* at the operator level. This kind of knowledge is an important capital for small industries because it allows workers

to adjust processes based on material conditions and production situations. However, if this knowledge is not documented, the sustainability of the production system becomes vulnerable to labor turnover (Johnson et al., 2019). Therefore, agro-industrial transformation needs to be followed by a knowledge codification process through SOPs, work instructions, process parameters, and problem-solving documentation. This is increasingly important because the post-harvest stages of cocoa, especially fermentation, drying, and storage, have a direct influence on the quality of cocoa beans. Control of the post-harvest process is very important because the activity of microorganisms during fermentation, drying, and storage can affect the quality of cocoa beans (Subroto et al., 2023).

From the perspective of occupational safety and health, this study shows that workers' awareness of hazards has been formed primarily through experience, but has not fully developed into a documented risk management system. These conditions show a difference between hazard awareness at the individual level and risk management at the organizational level. These findings are in line with a study that identified OSH training, commitment, risk management, communication, third-party support, and the role of the government as important factors in the implementation of the OSH system in MSMEs (Tejamaya et al., 2021). Thus, the limitations of the application of OSH in small agro-industries can not only be explained as a lack of worker discipline, but also related to the lack of a system that supports safe work behavior (Bluff, 2019; Tejamaya et al., 2021).

Findings regarding potential ergonomics issues also have important implications for technology design. Improvements to production equipment should not only be directed at increasing capacity or reducing processing time, but also at reducing physical load and improving human-machine interaction. Workplace design for manufacturing MSMEs in Indonesia needs to consider the specific characteristics of MSMEs in order to produce a safe, healthy, and productive work environment (Herwanto et al., 2024; Herwanto & Suzianti, 2023). Therefore, ergonomic aspects should be included from the early stages of technology design, including through high considerations of the field of work, operator range, style needs, frequency of movement, work posture, maintenance access, and safety when operating and cleaning tools.

The readiness of technology adoption found in this study also shows that ease of use and maintenance is part of the feasibility of technology, not just an additional factor. Business actors tend to need technology that can be understood by operators, does not require technical competencies that are too specialized, has operational costs that can be reached, and can be corrected in the event of disruptions. This finding is consistent with the concept *of technological appropriateness*, that technology for people with limited resources needs to be designed based on the context of the user and not only based on the technical capabilities of the technology (Sianipar, 2022). This emphasizes the importance of involving local stakeholders in all stages of design so that the resulting technology is in accordance with the needs and conditions of users (Steinke et al., 2022).

In the context of the cocoa agroindustry, technological suitability must also be linked to the goal of maintaining product quality. Technologies that increase process speed but are unable to maintain quality parameters do not necessarily provide the expected benefits. The fermentation and drying process is an important stage in determining the quality of cocoa beans, while improper drying can increase the risk of mold growth or affect the quality characteristics of the beans (Barrientos et al., 2019; Subroto et al., 2023). Thus, the technological needs in the smallholder cocoa agroindustry are not enough to be formulated as a need to increase productivity, but need to be directed at process control and quality consistency.

The supporting factors and obstacles found also show that the transformation of the smallholder cocoa agro-industry is a process that requires cross-actor support. Limited capital, technical knowledge, maintenance capabilities, and process standardization can hinder technology adoption even though business actors have the desire to develop (Bisheko & G, 2023; Ruzzante et al., 2021). On the other hand, the existence of mentoring, support from academics, farmer groups, and access to technology can strengthen the ability of business actors to make changes. The importance of the involvement of communities, experts, and other stakeholders in the development of technology for rural contexts (Sianipar, 2022; Steinke et al., 2022). This indicates that a transformation model that only provides equipment without assistance is potentially insufficient to guarantee the sustainability of technology use.

Based on the overall findings, this study indicates that the readiness for the transformation of the smallholder cocoa agroindustry is multidimensional. The first dimension is technological readiness, which includes the availability and suitability of equipment. The second dimension is human readiness, which includes the knowledge, skills, and capabilities of operators. The third dimension is work system readiness, which includes SOPs, process standardization, and quality control. The fourth dimension is safety readiness, which includes hazard identification, risk control, and ergonomics. The fifth dimension is institutional readiness, which includes support, mentoring, and the organization's ability to maintain the use of technology.

The findings provide a conceptual contribution that the transformation of the smallholder cocoa agro-industry should not be seen as a process of "replacing manual tools with machines", but as a process of socio-technical transformation. In this transformation, technology, people, production processes, occupational safety, and institutions must develop simultaneously (El Bilali, 2020). This perspective is important because technically successful technology does not necessarily produce sustainable change if it is not followed by user readiness and a supporting work system.

Practically, the results of the study provide the basis that technology development at the next stage needs to be carried out through a sequence of identification of user needs → mapping of the production process → identification of hazards and risks → determination of ergonomic needs → preparation of technology specifications → design and validation of users → training → implementation → post-implementation evaluation (Herwanto & Suzianti, 2023; Steinke et al., 2022; Tejamaya et al., 2021). Such an approach allows the developed technologies not only to meet technical requirements, but also to meet the needs of operators and the characteristics of small industries.

Thus, this study emphasizes that the sustainability of the smallholder cocoa agroindustry is not only determined by increasing production capacity and product quality, but also by the ability to create a production system that is safe, easy to use, in accordance with user capabilities, documented, and maintainable by business actors (El Bilali, 2020; Sianipar, 2022). This framework can be the basis for the development of appropriate technology and work systems in the smallholder cocoa agroindustry in Kulon Progo and other small agro-industry contexts that have similar characteristics.

CONCLUSION

This study shows that the readiness for the transformation of the people's cocoa agroindustry in Kulon Progo Regency is a multidimensional condition and is not only determined by the availability of technology. This readiness is influenced by the condition of the production system, the capacity and experience of human resources, the implementation of occupational safety and health (OSH), process standardization, the ability to receive and maintain technology, and institutional support. The agroindustry has the potential to be developed, but still faces limitations in production equipment, SOP documentation, work risk management, and technical capacity of business actors.

The application of appropriate technology needs to be directed at technology that is in accordance with the needs and capabilities of users. Ease of operation, maintenance, cost, ergonomics, operator safety, and technological ability to improve efficiency and quality consistency are important considerations in the transformation process.

DECLARATIONS

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The authors declare no conflicts of interest.

Ethical approval:
This study was approved by the Health Research Ethics Committee, Faculty of Nursing and Health Sciences, Universitas Muhammadiyah Semarang, Indonesia (Ethical Clearance No. 005/KE/05/2026). All participants received information about the study and provided informed consent before data collection. Participant confidentiality and anonymity were maintained throughout the research and publication processes.

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Data Availability Statement: The data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to ethical and confidentiality considerations.

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