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Article

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Competency mapping to develop human resources for Indonesia's sugarcane agroindustry in the Industry 4.0 era

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ABSTRACT

Modernisation of the sugar industry in Indonesia, particularly at the off-farm level, has been slow, with most sugar factories still using old factory machinery. However, this can be improved through the use of technology to build a sustainable sugar industry. Technological advances in the Industry 4.0 era require the preparation of professional human resources, ready to compete in the global arena. In relation to these conditions, this study aims to evaluate technology in the sugarcane production process and to map the competency units of human resources in the sugarcane production process. The research method to evaluate the technology in the sugarcane production process uses two decision-making methods, namely non-numerical and numerical decision-making. The recommendation obtained is that the cut-load-transport section is a priority technology to be replaced by a new technology. The results of the evaluation were then used to map the competence units of human resources in sugar production. Competency unit mapping was carried out in the cut-load-transport and milling sections and then combined by adopting the existing refined crystal sugar work competency standards. The results of the competency mapping design can be used by sugar factories to increase the productivity of human resources in sugar factories, which does not yet exist in Indonesia.

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1. Introduction

The decline of the sugar agro-industry was due to inefficiencies in cane growing, sugar factories and distortions in the international sugar market (Heryanto et al., 2020). However, future workers in the cane sugar agro-industry need to be considered with regard to certification in the Industry 4.0 era. In order to ensure the effectiveness of the sugar production process, it is strategic to manage individual competencies and map their development (Kipper et al., 2021; Rout et al., 2018; Takey & Carvalho, 2015) Human Resources (HR) in the Sugar Agro-Industry in the Industry 4.0 Era. In terms of HR certification and the cane sugar industry, there are no HR competency standards in the cane sugar sector in Indonesia (Mursiti et al., 2021). Because to produce quality sugar that meets the standards requires human resources who have the knowledge, skills, and work attitudes in operating equipment in the sugar production process. For this reason, efforts are needed to improve human resources in the industrial era 4.0. In order to ensure that HR competencies are in accordance with what is expected by the industry, it is necessary to evaluate the application of production process technology used by sugar factories today. This reason is one of the triggers for researchers to evaluate sugar production process technology and sugar cane competency standards.

In Indonesia, there is a competency standard for refined crystal sugar issued by the Decree of the Minister of Manpower of the Republic of Indonesia No. 178 of 2000 on the Determination of the Indonesian National Work Competency Standards for the Processing Industry Category of the Food Industry Principal Group of the Refined Crystal Sugar Industry in the Quality Control and Production Sub-Sector. This research aims to evaluate the sugar production process technology that needs to be

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replaced with new technology and to map the human resource competency units in the sugar production process. Rangnekar (2020) emphasises the understanding of different skills and how these skills are used by employees to contribute to the organisation. Given the importance of HR associated with certifications such as certifications in graphic design schemes, computer operators and others. The researcher proposes here the process of designing human resource competency mapping in the cane sugar production process.

The method used to evaluate the sugar production process technology to be replaced by new technology uses 2 methods, namely non-numerical and numerical decision making. The results of both methods are used to compare the results of the recommendations obtained. The non-numerical decision making used is multi-expert multi-criteria decision making (MEMCDM). The results of both non-numerical and numerical decision-making methods show that cut-load-transport is a priority process technology in sugar production that needs to be replaced by new technology. The methodology for formulating competency standards is at least proven by a training certificate for formulating Indonesian national competency standards. The technical content is proven by relevant experience; company recognition or recommendation; certificate of competence. This research is limited to competency mapping, which is arranged in an order of job functions that include main objectives, key functions, main functions, and basic functions or units of competence. The formulation can be done by field research, adaptation or adoption. The formulation of competency mapping is verified and validated. The purpose of competency mapping is to identify and map the units of competence of an industry sector that need to be compiled into competency standards.

2. Literature review

2.1. Agriculture 4.0

Agriculture 4.0 is an inevitable trend in modern agriculture. The foundations of Agriculture 4.0 are the Internet of Things, big data, artificial intelligence, cloud computing and connectivity (Albiero et al., 2020). Agriculture 4.0 is expected to increase agricultural yields, save input costs, and in many situations reduce human resources. Agriculture 4.0 is expected to increase agricultural yields, reduce input costs and, in many situations, reduce human resources. Agriculture 4.0 is also expected to improve environmental health by increasing food production on existing land and improving eco-efficiency (Ehlers et al., 2022). In addition, the contribution of the agricultural sector to Indonesia's GDP is quite high at 13.22% and has shown the ability to maintain positive growth during the Covid-19 pandemic (BPS, 2022).

The development of national industry in 2020–2024 is geared towards the implementation of Making Indonesia 4.0, which focuses more on five industrial sectors, namely: (1) food and beverages; (2) textiles and fashion; (3) automotive; (4) chemicals; and (5) electronics (Bappenas, 2020). Mastering science and technology and innovation in line with Industry 4.0 is the key to a nation's global competitiveness in the future. According to Alhloul and Kiss (2022), Industry 4.0 has ten main technologies that drive this revolution as follows (1) Industrial Internet of Things (Araújo et al., 2021; Fatimah et al., 2023; Harry, 2020; Raj et al., 2021); (2) industrial cloud computing (Bello et al., 2021; Oruma et al., 2021); (3) big data (Chowdhury et al., 2020); (4) simulation (Asrol et al., 2021; Raj et al., 2021; Zhai et al., 2020); (5) augmented reality (Alam et al., 2023; Kipper et al., 2021; Liu et al., 2023); (6) additive manufacturing (Alcácer & Cruz-Machado, 2019; Blayone & VanOostveen, 2021; Fonseca, 2018; Hahn, 2020); (7) horizontal and vertical system integration (Fuertes et al., 2022; Hasbullah et al., 2021; Pérez-Lara et al., 2019); (8) artificial intelligent (Fatimah et al., 2023; Fachrunnisa & Hussain, 2020; Flores et al., 2020; Zhang & Lu, 2021); (9) cybersecurity (Aldhyani & Alkahtani, 2023; Stachová et al., 2020; Silva et al., 2023); (10) cyber-physical system (Kadir & Broberg, 2021; Luthra et al., 2020).

2.2. Skills 4.0 for human resources

Competence is an individual's ability to work and includes aspects of knowledge, skills and attitudes that are in line with expected standards (Jaskiran Kaur et al., 2023). Another definition is that competence is something related to the ability and skills of individuals to achieve expected results (Lambert & Bouchamma, 2019). Competence is a combination of a person's attributes, abilities, skills, knowledge and

experience required to perform roles in life and work (Hecklau et al., 2016). Based on this definition, some important things related to competence are knowledge, attitudes, understanding, values, talents or skills and interests. Competences can also be defined as individual characteristics that can be measured and determined to indicate certain behaviour and work performance in an individual. Competence is therefore a guide for organisations to indicate the right job function for an employee. Competencies are related to attitudes (what a person says and does) that indicate a person's performance is good or bad.

The rapid advancement of communication and information technologies in the psycho-social structure of societies, cities and industries through smartphones, IoT and AI is due to their perceived ease of use and cost savings. This has led to their widespread use, resulting in an increasing dependency on these functions. It can be said that people are now in an almost symbiotic synergy with digital technology (Albiero et al., 2020). For this reason, improving the skills of the workforce is important for increasing industrial productivity in the Industry 4.0 era (Chrysosolouris et al., 2013). Competence is a combination of a person's attributes, abilities, skills, knowledge and experience required to perform a job (Meyer et al., 2015). According to Miao et al. (2017) that digital skills and emotional intelligence have a proven impact on job performance. According to Flores et al. (2020) that HR competencies include (1) soft competencies, (2) hard competencies, (3) cognitive competencies, (4) emotional competencies, and (5) digital competencies. Soft competence is a collection of traits that reflect a person's social gifts in a particular environment (Haeffner & Panuwatwanich, 2018). Hard skills, also known as technical skills, are the skills and knowledge required to carry out a trade, craft or occupation that requires special skill, training or experience (Robles, 2012). Cognitive ability, or intelligence quotient (IQ), is the intellectual ability that enables learning to support the mastery, skill and performance of specific tasks (Kautz et al., 2014). Emotional skills or emotional intelligence is the ability to understand and regulate one's emotions, which is expected to lead to success through better ability to cope with new challenges and resilience to frustration and stress (Rezvani et al., 2016). Digital literacy is the ability to understand and use digital content, devices and systems to carry out activities.

Vuorikari et al. (2016) has developed a framework that addresses five areas of digital literacy development, as shown in Table 1. The framework provides a very comprehensive view, covering all digital skills and activities, primarily in five areas and two dimensions.

In relation to the certification of personnel in the cane sugar agro-industry, it was found that there is no regulation on the standards of work competence in the cane sugar agro-industry, let alone the levelling of positions in sugar factories (Mursiti et al., 2021). This is important to ensure the competence of the workforce to perform their duties correctly and well. In relation to work competency standards in Indonesia for the sugar industry, the government has issued Decree of the Minister of Manpower of the Republic of Indonesia No. 178 of 2020 on the determination of Indonesian national competency standards category of processing industry main group of food industry in the field of refined crystal sugar

Table 1. DigComp 2.0 framework for five digital skill areas.

Dimension 1	Dimension 2
1. Information and data literacy	<ol style="list-style-type: none"> 1. Browse, search and filter data 2. Evaluate data, information and digital content 3. Manage data, information and digital content
2. Communication and collaboration	<ol style="list-style-type: none"> 1. Interact, share and collaborate through digital technology 2. Citizenship through digital technology 3. Netiquette 4. Digital identity management
3. Digital content creation	<ol style="list-style-type: none"> 1. Digital content development 2. Integrate and repurpose digital content 3. Copyright and licences 4. Programming
4. Safety and security	<ol style="list-style-type: none"> 1. Protecting the unit 2. Protection of personal data 3. Protect health and well-being 4. Protecting the environment
5. Problem solving	<ol style="list-style-type: none"> 1. Solving technical problems 2. Identify technology needs and answers 3. Creative use of digital technology 4. Identify digital skills gaps

Source: Vuorikari et al. (2016).

industry in the subfield of quality control (Decree of the Minister of Labour RI No 178 Year 2020 about the Determination of Indonesian national competency standards Category Processing Industry Main Group Food Industry Refined Crystal Sugar Industry Sector, 2020). Cane sugar and refined sugar have similarities and differences, the similarity being as a sweetener. The difference lies in the production process, product standards and labelling. In the production process, cane sugar has a longer stage, there is sugar cane harvesting and sugar cane milling, but the production process after milling is the same. In terms of quality, cane sugar has a lower colour standard than refined sugar. In Indonesia, cane sugar is consumed by households and refined sugar by the food and beverage industry.

Previous research on competency mapping has proposed a seven-step method for project management competency maps (Takey & Carvalho, 2015). Explore the extent to which competency mapping can assist in analysing gaps in required skills and be followed up to improve competency levels (Jaideep Kaur & Kumar, 2013), learn how competency mapping can be used to analyse the mix of skills of different people to create the most cohesive teams and produce higher quality work (Jaskiran Kaur et al., 2023), describes a new mapping software that simplifies and standardises the competency mapping process (Holmes et al., 2018), discuss the implications of the recent competency mapping project for education and training programmes for public health workers (Coombe et al., 2022), explore the integrated relationship between talent acquisition competency mapping and performance management and appraisal in the Indian context (Rangnekar, 2020), no standardised benchmarks for achieving competence and open to individual interpretation (Perera et al., 2013).

3. Research methods

The research began with an evaluation of sugar production process technology in one sugar factory and all Indonesian sugar factories. This was done to compare the research results of the two research objects regarding the similarities and differences between them. The data processing techniques used are non-numerical multi-expert multi-criteria decision making and numerical decision-making methods. The data obtained is primary data through distributing questionnaires with different instruments for both. The preparation of the instrument is based on the research objectives and has been verified by experts. The experts selected here have predetermined qualifications. The qualifications include (1) the expert has experience in the sugar industry for at least 10 years, (2) has a position equivalent to manager and above, (3) has competence recognition in the sugar industry from external parties. Furthermore, the research results obtained from the two objects were used as a consideration to compile the mapping of sugar cane agro-industry competency units. Other considerations used to compile this unit of competency mapping are Indonesian national competency standards Refined Crystal Sugar Bidang Quality Control and Production which includes the process of purification, evaporation, crystallisation, separation and completion.

In Figure 1, before conducting the competency mapping, the researchers first evaluated the technology of the sugar production process to find out which part of the technology requires new technology. The evaluation was carried out on sugar factories that have not implemented 4.0 technology and all sugar factories throughout Indonesia using 2 (two) different methods, namely non-numerical multi-expert multi-criteria decision making and numerical decision making through questionnaires with different instruments with the same purpose. The questionnaire was sent to experts in sugar factories with predetermined criteria. The criteria are (1) having at least a managerial position, (2) having at least 10 years of experience in the sugar sector, and (3) having sugar-related expertise recognised by others. Questionnaires were distributed to 3 (three) experts in August 2022 and to all 62 Indonesian sugar factories that have not implemented 4.0 technology, and 34 questionnaires were returned in January 2023.

In addition, the data obtained were recapitulated, processed and analysed for comparison in terms of population, methods and results obtained. The comparison of the results of the two surveys showed that cut-load-transport is a priority that requires new technology. The next analysis is of the SKKNI in the area of refined crystal sugar. The Indonesian National Competency Standard (SKKNI) is a formulation of work ability that includes aspects of knowledge, skills and/or expertise as well as work attitudes that are relevant to the performance of the duties and requirements of the specified position. The analysis of standards in the field of refined crystal sugar begins with an analysis of the mapping of units of competence in the field of refined crystal sugar. Competency mapping is a comprehensive description of each function in a business area that is used. The results of the refined crystal sugar competency mapping analysis

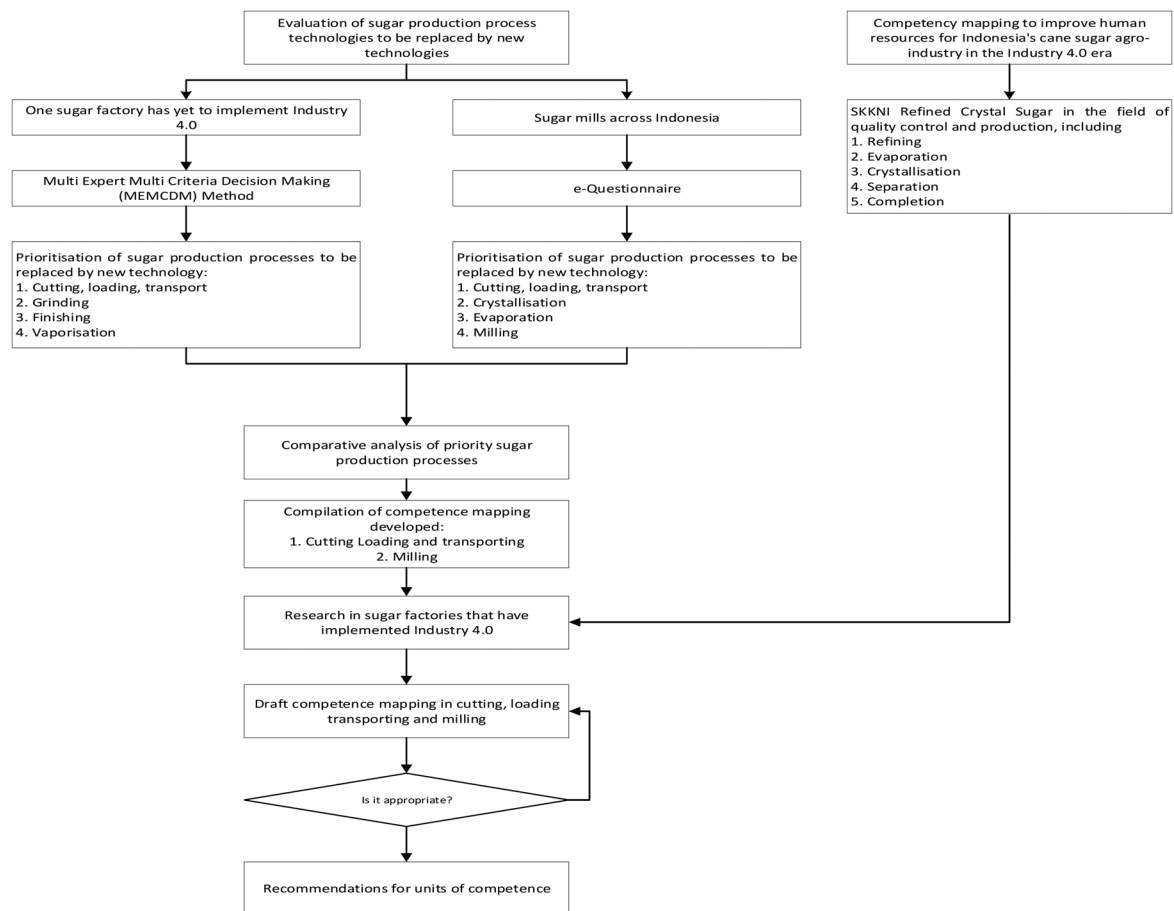


Figure 1. Research Methods.

show that the sugar production process that has been compiled starts from refining, evaporation, crystallisation, separation and completion. While cut-load-transport and milling are not included in the refined crystal sugar standard because it does not go through the process. The two parts, cut-load-transport and milling, are the differences in the production process between refined crystal sugar and white crystal sugar. These two parts will be the focus of this research to map HR competences in slash load transport and milling in the field of white crystal sugar or cane sugar.

Research on the mapping of cane sugar competence units was conducted in a cane sugar factory that has implemented 4.0 technology. The research object is located in the Blitar area, East Java, Indonesia. The research object is adapted to the research objectives, namely to map the competency units of the HR of the cane sugar agroindustry in the industrial era 4.0 with a focus on the cut-load-transport and milling sections. The research on competence mapping starts with the creation of a group or working team involved in the preparation of the mapping of competence units. The working team consisted of department heads from the cut-load-transport, milling, quality control, refining, evaporation, crystallisation, separation and white crystal sugar finishing departments. Each department was then asked to write down all the activities carried out as a starting point for the draft competency mapping. Furthermore, the draft competency mapping was verified and validated through Focus Group Discussion (FGD) activities in a sugar factory in Blitar, East Java, Indonesia.

4. Results and discussion

4.1. Assessment of cane sugar production technology

Prior to the mapping of the competence units, the researchers carried out an evaluation of the sugar production process technology in need of new technology. The evaluation was conducted using two (2) methods, namely (1) non-numerical multi-expert multi-criteria decision making and (2) numerical

decision making through questionnaires. The research object was conducted for two (2) research objects, namely (1) 1 sugar factory in Eastern Indonesia and (2) 34 sugar cane factories throughout Indonesia. There are two (2) methods used, namely (1) Non-numerical Multi Expert Multi Criteria Decision Making (ME-MCDM) used for PG in Eastern Indonesia, and (2) Numerical decision making used for 34 sugar mills in Indonesia using questionnaires. ME-MCDM was chosen because it is one of the non-numerical methods and is suitable with the advantages of using multiple experts and multiple criteria to become an aggregation decision. The numerical decision-making method is used in contrast to the non-numerical decision-making method. The aim is to convince the researchers that the results of the evaluation of the cane sugar production technology from both methods have differences and similarities in different aspects.

4.1.1. Non-numerical multi-expert multi-criteria decision making

The basic logic of Yager's MEMCDM method is that criteria with low importance will have little effect on the total value, while criteria with high importance will contribute significantly to the total value (Verna et al., 2023). This decision-making technique is used to determine alternative prioritisation of cane sugar production process technology that requires new technology. This method begins with the formulation of a problem that will be discussed first through literature review and discussion with experts who know the cane sugar agro-industry. Alternatives and assessment criteria are also developed together with experts. Figure 2 below illustrates the stages of research using the non-numerical ME-MCDM method.

4.1.1.1. Data analysis techniques. The expert evaluation of the criteria is carried out by determining the degree of importance of the criteria for each alternative sugar production process using Equation (1).

$$Neg(W_k) = (W_{q-k+1}) \quad (1)$$

$Neg(W_k)$: negation of the weight value of criterion k

k: index (1, 2, 3, 4, 5)

q: number of scales

The aggregation process on the criteria uses Equation (2).

$$V_{ij} = \min[Neg(W_{ak}) \vee W_{ij}(a_k)] \quad (2)$$

V_{ij} : the value of the i-th alternative by the j-th expert

$W_{ij}(a_k)$: the value of the i-th alternative by the j-th expert on the k-th criterion

The value weight is determined using Equation (3).

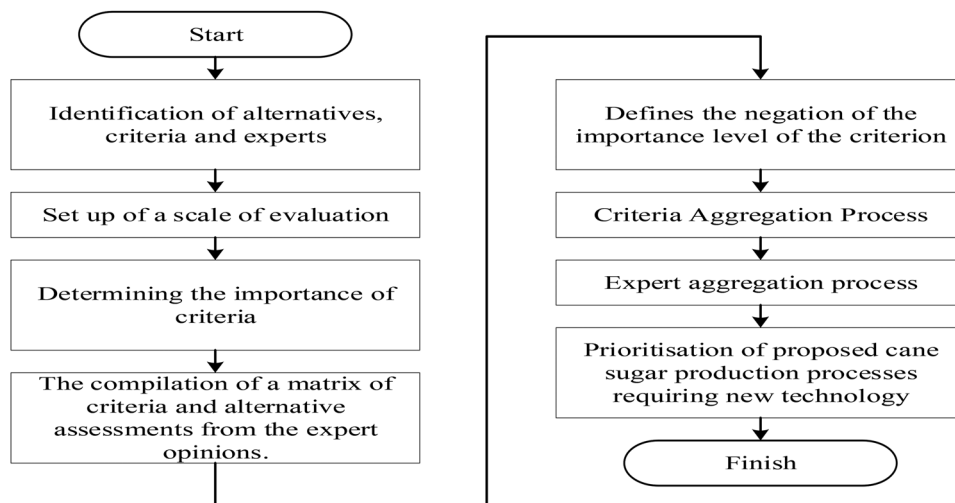


Figure 2. Stages of research into recommendations for cane sugar production processes requiring new technology.

$$Q_k = \text{Int}\left[1 + \left(k \times \frac{q-1}{r}\right)\right] \quad (3)$$

Q_k : k-value weight

Int : integer

R : number of experts

The process of aggregating experts is done using Equation (4).

$$V_i = f(V_i) = \max[Q_j \wedge b_j] \quad (4)$$

V_i : The process of aggregating experts is done using equations.

Q_j : j value weight

b_j : The order of the highest value from the jth expert judgement.

4.1.1.2. Data collection and processing. Expert opinion was used to generate recommendations for prioritised production processes requiring new technology. The experts used were 3 experts from the sugar factory under study in Eastern Indonesia with pre-determined qualifications. The qualifications of the experts used are (1) at least a managerial position; (2) has 10 years of cane sugar experience; (3) has recognition related to cane sugar. The following is Table 2 of alternative cane sugar production processes that are the subject of research.

In addition, the rating scale for the evaluation of the seven alternatives is determined with 5 ratings, namely Perfect (P), Very High (VH), High (H), Average (A), Low (L). The negation of the rating scale is calculated using Equation (1) P to L, VH to A, H to H, S to VH and L to P. The level of importance of the criteria is an assessment given by 3 (three) experts for each criterion, then the final assessment is averaged to obtain the final results of the assessment of each criterion, which can be seen in Tables 3 and 4.

Based on expert opinions, the aggregation of criteria for each alternative cane sugar production process is calculated using Equation (2) to obtain the calculation for each alternative.

1. Alternative: cut-load-transport

Aggregation of criteria

$$\begin{aligned} V_{11} &= \min[A \vee H, L \vee H, H \vee L, A \vee H, A \vee P, VH \vee P] \\ &= \min[H, H, H, H, P, P] = \mathbf{H} \end{aligned}$$

$$\begin{aligned} V_{21} &= \min[A \vee A, L \vee VH, H \vee A, A \vee L, A \vee L, VH \vee L] \\ &= \min[A, VH, H, A, A, VH] = \mathbf{A} \end{aligned}$$

$$\begin{aligned} V_{31} &= \min[A \vee A, L \vee VH, H \vee A, A \vee L, A \vee L, VH \vee L] \\ &= \min[A, VH, H, A, A, VH] = \mathbf{A} \end{aligned}$$

Weight value by using Equation (3)

$$Q_1 = \text{Int}\left[1 + \left(1 * \left(\frac{5-1}{3}\right)\right)\right] = 2 = \mathbf{A}$$

$$Q_2 = \text{Int}\left[1 + \left(2 * \left(\frac{5-1}{3}\right)\right)\right] = 4 = \mathbf{VH}$$

Table 2. Alternative for cane sugar production process.

No	Alternative cane sugar production processes
1.	Cut load transport
2.	Milling
3.	Refining
4.	Evaporation
5.	Crystallisation
6.	Separation
7.	Completion

Table 3. Criteria level of importance and negation of level of importance.

Criteria affecting yield	Expert-1		Expert-2		Expert-3		Average	Expert judgement	Negation of expert judgement
1. Number of losses	VH	4	VH	4	P	5	5	VH	A
2. Waiting time	P	5	P	5	VH	4	5	P	L
3. Distance from – to	A	2	VH	4	VH	4	4	H	H
4. Sugar cane hygiene	VH	4	VH	4	VH	4	4	VH	A
5. Machine malfunction	P	5	L	1	P	5	3	VH	A
6. Minimum quantity of sugarcane per day according to milling capacity	P	5	L	1	VH	4	3	A	VH

Table 4. Results of the expert assessment of alternative cane sugar production processes.

Expert	Alternative	Evaluation criteria					
		1	2	3	4	5	6
Expert 1	1. Cut-load-transport	H	H	L	H	P	P
	2. Mill	P	VH	L	VH	P	VH
	3. Refining	P	P	L	VH	P	VH
	4. Evaporation	VH	VH	L	VH	P	VH
	5. Crystallisation	P	H	L	L	P	H
	6. Separation	A	VH	L	VH	P	A
	7. Completion	L	L	L	L	P	L
Expert 2	1. Cut-load-transport	A	VH	A	L	L	L
	2. Mill	L	L	L	L	L	L
	3. Refining	A	L	A	H	L	A
	4. Evaporation	L	L	L	H	L	A
	5. Crystallisation	P	P	L	VH	L	H
	6. Separation	H	H	A	H	A	A
	7. Completion	H	A	A	L	L	L
Expert 3	1. Cut-load-transport	P	VH	VH	P	P	VH
	2. Mill	P	P	VH	VH	P	P
	3. Refining	P	VH	VH	VH	P	VH
	4. Evaporation	P	VH	VH	VH	P	VH
	5. Crystallisation	P	VH	VH	VH	P	VH
	6. Separation	P	VH	VH	VH	P	VH
	7. Completion	P	VH	VH	VH	P	VH

$$Q_3 = \text{Int} \left[1 + \left(3 * \left((5 - 1) / 3 \right) \right) \right] = 5 = \mathbf{P}$$

Expert aggregation by using Equation (4)

$$x_j = A, VH, P, \text{ sehingga } b_j = P, VH, A$$

$$V_1 = \max[H \wedge P, A \wedge VH, A \wedge A] \\ = \max[H, A, A] = \mathbf{H}$$

The final score of alternative 1. cut-load-transport is H (high).

The same calculation is also carried out for alternative 2. milling up to alternative 7. completion, which is done in the same way. The final results for each alternative are shown in [Figure 3](#).

[Figure 3](#) above shows that the technological priorities of the sugar factory production process requiring new technology with category H (high) there are 4 namely (1) cut-load-transport, (2) milling, (3) refining and (4) evaporation; category A (equal) there are 3 namely (1) crystallisation, (2) separation, (3) finishing. The results of the expert evaluation of the alternative sugar production processes resulted in 2 out of 5 categories. For category H (high), 4 alternatives are obtained, but among the 4 alternatives, it is not clear which order has priority, which means that the 4 alternatives have to be run simultaneously. Similarly, for category A (equal), 3 alternatives were obtained, but among the 3 alternatives it is not clear which order has priority, which means that they are equal, although there is actually a slight difference.

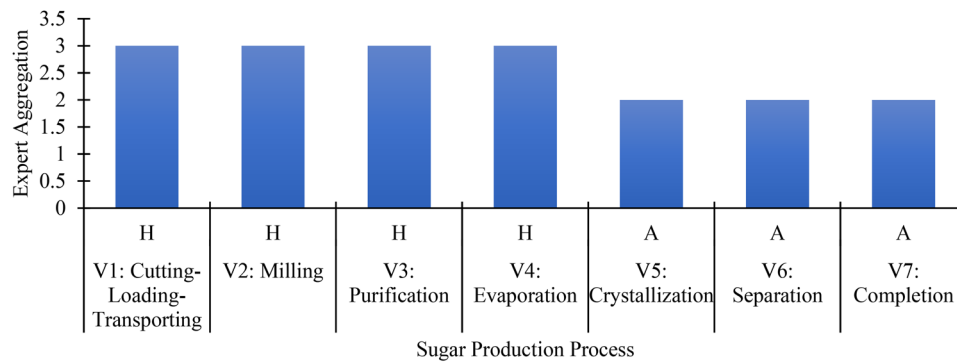


Figure 3. Diagram of final judgement by experts on production process technologies that require new technologies.

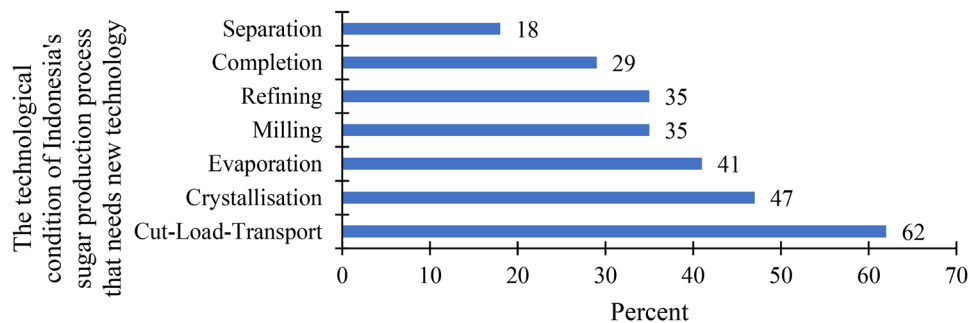


Figure 4. Technological prioritisation of cane sugar production in Indonesia, which requires new technologies.

However, the results of the recommendations obtained are still up to the sugar factory to decide, as the limitations of the sugar factory are not included in this calculation.

4.1.2. Numerical decision making

Data collection in research must be done scientifically and systematically. This study conducted a survey by distributing questionnaires or surveys as research instruments, where the questionnaire is an effective and efficient forum for collecting data to be measured numerically.

4.1.2.1. Data collection and processing. Expert opinion was used to develop recommendations for priority production processes requiring new technology. Data was collected using a questionnaire distributed to 62 sugar factories in Indonesia, and 34 questionnaires were returned to be used as research data. The qualifications of the experts who completed the questionnaire were determined by the following conditions: (1) at least a managerial position; (2) 10 years of cane sugar experience; (3) recognition related to cane sugar. Microsoft Excel was used for data analysis. The following results of data collection and processing from 34 cane sugar factories can be seen in Figure 4.

From the above Figure 4, it can be seen that the priority of cane sugar production technology requiring new technology is as follows, in order: (1) cut-load-transport by 62%, (2) crystallisation by 47%, (3) refining by 41%, (4) milling by 35%, (5) refining by 29%, (6) completion by 29% and (7) separation by 18%. Based on the data processing and analysis visualised in Figure 4, the state of sugar mills in Indonesia shows that cut-load-transport technology is the priority requiring new technology. This is followed by crystallisation, evaporation, milling, finishing, evaporation and separation. However, the results of the recommendations obtained are still up to the sugar factories to decide, as the limitations of the sugar factories are not taken into account in this calculation.

Furthermore, data processing and analysis was carried out between the two research objects, the priority of sugar production processes to be replaced by new technology is the same, namely cut-load-transport. The results of the comparison of the cane sugar production process technology to be replaced by new technology of the two research objects together with the Indonesian national competency

standards for refined crystal sugar in the context of competence mapping in the cane sugar agro-industry can be seen in [Table 5](#).

[Table 5](#) shows a comparison of the results of the evaluation of the sugar production process using 2 (two) methods (non-numerical decision making and numerical decision making) with 2 (two) research objects, namely 1 (one) sugar mills in Eastern Indonesia and 34 (thirty-seven) sugar mills throughout Indonesia. It was found that the same results were obtained with both methods with both research objects, that is, that the slab transport section is a priority that requires new technology. This result was also confirmed by experts, and the cut-load-transport section does require new technology compared to other parts of the sugar production process. This is because the status of sugarcane land in Indonesia consists of 3 ownership statuses, namely (1) large state plantations, (2) large private plantations and (3) smallholder plantations. In 2021, Indonesia's sugarcane area will be 449 hectares (BPS, [2022](#)) with the largest composition of smallholder plantations (59%), large private plantations (30%) and large state plantations (11%). As a result, the majority of cane harvesting activities is carried out by farmers using manual rather than mechanised equipment.

In terms of loading activities, the sugar cane production line during harvesting, where the sugar cane fields are generally in the middle of the field and have to be moved to the lane to be loaded onto the truck, is also done manually and few use technological aids such as three-wheeled conveyors or lorries to transport sugar cane by rail. For transport activities, the problems are more related to the road infrastructure, which needs to be improved and repaired, which is considered to increase sugar production. According to Freitas et al. ([2019](#)). In his research on cut-load-transport, he suggested a 40% reduction in the time spent waiting for sugarcane to be transported. The cause of the long waiting time for sugarcane to be milled at the mill terrace is the variability of the land, which results in inefficient use of felling and transport labour. There are 5 proposed solutions, namely (1) integration of computer system and traffic control system; (2) integration of harvester on-board computer with transporter; (3) application of truck filling volume sensor; (4) command-based management; (5) assignment of one person with different tasks; (5) assignment of one person with different tasks.

4.1.3. Mapping competency units in sugar cane factories with 4.0 technology

The purpose of this section is to design a mapping of HR competency units for the cane sugar agro-industry in the industrial era 4.0. The considerations used before mapping the HR competence units in the cane sugar agroindustry are (1) the results of the situation analysis from the HR aspect in the form of the need for competence infrastructure in the cane sugar agroindustry, (2) the results of the evaluation from the technological aspect that cut-load-transport as a priority technology that requires new technology, and (3) the analysis and adoption of Indonesian national competency standards in the field of refined crystal sugar that the milling part is a part of the production process that refined crystal sugar does not have due to differences in raw materials in the production of sugar.

From the results of the evaluation of cane sugar production technology, it is found that cut-load-transport is a priority technology that requires new technology. This reason encourages the author to conduct a mapping of HR competency units in the cane sugar agro-industry with a focus on the cut-load-transport and milling sections. While the part outside the cut-load-transport and milling adopts Indonesian national

Table 5. Comparison of sugar production process evaluation results with 2 (two) methods.

Aspects	Subject of research	
	Sugar mills in Eastern Indonesia	Sugar mills in western Indonesia
Number of respondents	3 experts from 1 sugar mills	34 experts from 34 sugar mills
Methods	Non-numerik MEMCDM	Numerical decision making (Ms Excel)
Results	Category H (High): <ul style="list-style-type: none"> • Cut-load-transport • Milling • Refining • Evaporation Category A (medium): <ul style="list-style-type: none"> • Crystallisation • Separation • Completion 	Priority order: <ol style="list-style-type: none"> 1. Cut-load-transport 2. Crystallisation 3. Refining 4. Milling 5. Completion 6. Evaporation 7. Separation

competency standards in the field of refined crystal sugar which includes quality control and production (purification, evaporation, crystallisation, separation, and completion). The research was conducted in one of the sugar factories in Blitar which is considered to have implemented 4.0 technology. Some considerations why this sugar factory is the subject of research because this factory is one of the new factories that use modern machinery such as the use of (1) tandem mill sets; (2) process stations; (3) robotic bagging; (4) boilers and turbine generators; (5) quality control laboratories using digital equipment.

The stages of competency unit mapping are (1) perception equalisation by providing a comprehensive understanding of the competency mapping programme, (2) conducting competency mapping by conducting sector/business group analysis and productive function analysis (main objectives, key functions, main functions and basic functions), (3) draft competency unit mapping of cane sugar agroindustry HR work competencies, (4) verification of draft competency unit mapping in FGDs, and (5) draft competency unit mapping that has been verified. Competency mapping will be carried out through the formation of a working group whose role and function will be to carry out the competency mapping activities in accordance with the terms of reference. The members of the working group in this study are the factory manager and his subordinate managers in a WhatsApp group to facilitate coordination and communication. The formulation of the unit competency mapping design was carried out using field research, adaptation and adoption methods. The role of the researcher here is from a methodological aspect by having a certification of training in the preparation of work standards, while the team members from the sugar factory from the content aspect of unit competency mapping.

Supporting data needed such as organisational structure, number of employees and company profile, distribution of questionnaires in the form of google forms to find out the duties and functions of each position in cut-load-transport and milling, and the need to form a WhatsApp group for coordination. The format of the competency unit mapping is based on the format of the Indonesian Ministerial Regulation No. 3 of 2016 on Procedures for Determining Indonesian National Work Competency Standards. Verification of the draft competency unit mapping was conducted through focus group discussions (FGD) at the sugar factory. The following results of the verified competency unit mapping are shown in [Table 6](#).

The positions in the On Farm Department of the cut-load-transport section are Zone Operator, Logistics Operator, Harvest Operator, Zone Shift Head, Logistics Shift Head, Section Head Zone, Plant Zone Manager, and Logistics Manager. Positions in the quality control department are Process Control Analyst, Product Analyst, Water Treatment Analyst, Incoming Material Analyst, Waste Analyst, Microbiological Analyst, Regular Foreman, Shift Foreman, Shift Head, Super Intendent, Assistant Manager, Manager. Positions contained in the production department of the milling section are DCS Mill Operator, Field Mill Operator, Lubricant Operator, Tipper Operator, Scrapper Operator, Cane Preparation Operator, Shift Head, Super Intendent, Assistant Manager, Manager. Positions contained in the production department of the process section are Afination Operator, Carbonation Operator, Filtration Operator, IER Operator, Evaporator Operator, Vacuum Pan Operator, Centrifugal Operator, Drying and Cooling Operator, and Packing Operator, Afination Foreman, Carbonator-Filtration-IER Foreman, Evaporator & Vacuum Pan Foreman, Centrifugal-Drying-Cooling Foreman, Packing Foreman, Decolorisation Supervisor, Centrifugal Supervisor, Boiling/Vacuum Pan/Crystallisation Supervisor, Bagging Supervisor.

Based on [Table 6](#) above, the role of the On-Farm cut-load-transport Department is to ensure that manual cut-load-transport activities comply with standards and are carried out effectively and efficiently. The Quality Control Department inspects raw materials, process materials, process materials and finished products. The Mill Production Department operates the mill unit to milk the cane as much as possible to separate it from the pulp and to minimise the sugar content in the pulp. The process section of the production department effectively and efficiently manages all production management in the refining, evaporation, crystallisation, separation and completion sections. The unit of competence mapping contains basic functions, hereafter referred to as units of competence. The unit of competence is the output of the position in the department.

[Table 7](#) illustrates the number of units of competency in the cut-load-transport and milling section. The number of units of competence in the cut-load-transport and milling section is 57 titles of units of competence that have been verified and validated by the internal sugar cane factory which is the object of research. This draft list of competency units can also be used by internal sugar factories that are the object of research as well as an initial design for the white crystal sugar industry to continue as a unit

Table 6. Competency unit mapping.

Main objective	Key function	Main function	Basic function
Processing of sugar cane into white crystal sugar in accordance with the Indonesian national standard	Dept. QA – QC	Quality control of raw materials, process materials, process materials and finished products	Clean of the test laboratory *
			Clean up chemical spills *
			Maintain the working environment of analytical instruments *
			Maintain analytical balance *
			Prepare reagent solution according to procedure (daily)*
			Prepare standard solutions according to procedures (daily)*
			Store chemicals safely *
			Dispose of reagent waste in accordance with procedure *
			Take samples from sample points*
			Take a test sample/subsample of the sample at the point of sampling *
			Filing of samples *
			Prepare samples for chemical analysis *
			Perform conventional titrimetry analysis in accordance with procedure *
			Performance of titrimetric analysis in non-aqueous media in accordance with procedures *
			Performance of conventional gravimetric analysis in accordance with procedure *
			Performance of conventional gravimetric analysis in accordance with procedure *
			Performance of spectrophotometric analysis in accordance with procedures *
			Polarimeter operation in accordance with analysis requirements ***
			Operate refractometer in accordance with analysis requirements ***
			Operating the Dry Oven for moisture analysis ***
			Operate the Moisture Analyser ***
			Operate the pH meter ***
			Operate the Conductivity meter ***
			Perform colour analysis ***
			Perform CO ₂ content analysis ***
			Operate a bomb calorimeter for coal analysis ***
			Operate a coal grinder/crusher for sample preparation ***
			Perform turbidity analysis ***
			Perform particle size analysis on sugar products ***
			Make distilled water with a distiller ***
			Perform sediment analysis ***
			Perform colourimetric analysis according to the procedure *
			Calibrate of analytical balance(s)*
			Make Certificate of Analysis (CoA) products ***

Main objective	Key function	Main function	Basic function
		Control microbiological quality	<p>Control of the microbiological quality ***</p> <p>Prepare seeding media for Microb *</p> <p>Carry out sterilisation process in accordance with procedure *</p> <p>Perform aseptic technique *</p> <p>Perform microbial inoculation and subculture *</p> <p>Perform pathogenic microbial analysis **</p> <p>Carry out room and equipment sanitising tests *</p> <p>Perform microbiological water quality testing *</p> <p>Perform microbiological sugar quality testing ***</p> <p>Operate the Laminer Airflow device ***</p> <p>Conduct total microbial determination by TPC **</p> <p>Supervise sampling and analysis ***</p> <p>Write a report on the results of the analysis *</p> <p>Carry out interpersonal communication *</p> <p>Control the recording of analysed data *</p> <p>Verify of results <i>Certificate of Analysis (CoA)</i>***</p> <p>Ensure that products meet the required standards ***</p> <p>Make Monthly Report ***</p> <p>Review of the daily report in relation to the analysis results and plant performance ***</p> <p>Evaluation of process material and utility consumption rates in accordance with company standards ***</p> <p>Implement a work supervision system *</p> <p>Manage the ordering process for chemicals and laboratory equipment *</p> <p>Implement a process for repairing analytical instruments using third parties *</p> <p>Documentation of all quality control activities *</p> <p>Coordinate activities of <i>Good Laboratory Practice (GLP)</i> *</p> <p>Implementation of a work control system *</p> <p>Create a tool operating manual *</p> <p>Preparation of work instructions for chemical analysis *</p> <p>Evaluate the analysis results *</p> <p>Validate the analysis method * (Carry out Test Method Validation/Verification Following Procedure)</p> <p>Determine the uncertainty value of the analysis *</p> <p>Development of test methods *</p> <p>Specify test methods for health and safety equipment (K-3) *</p> <p>Evaluate sampling points ***</p>
		Conduct of supervision	
		Carry out supervision and evaluation of laboratory performance	

(Continued)

Table 6. Continued.

Main objective	Key function	Main function	Basic function
		Perform laboratory work scheduling	<p>Conduct analysis of workforce development ***</p> <p>Develop a laboratory work plan ***</p> <p>Develop a plan Developing a budget plan on a periodic basis ***</p> <p>Evaluate the performance of QC and QA personnel ***</p> <p>Define the roles and functions of laboratory staff *</p> <p>Plan the analytical quality control system *</p> <p>Verify product release ***</p> <p>Planning for cut-load-transport activities</p>
Department on the Cut-Load-Transport Section	Carry out work planning for cut-load-transport		
	Organise cut-load-transport activities		<p>Coordinate the implementation of cut-load-transport activities</p> <p>Plan a budget for cut-load-transport activities</p> <p>Plan the target of cut-load-transport activities</p> <p>Analyse cut-load-transport problems and their solutions</p> <p>Prepare a budget plan for cut-load-transport</p> <p>Set up targets for cut-load-transport activities</p> <p>Prepare a risk mitigation plan for cut-load-transport activities</p> <p>Coordinate cut-load-transport activities</p> <p>Evaluate cut-load-transport activities</p> <p>Plan operator tasks and targets in each zone</p> <p>Control of farmer registration</p> <p>Control of farmer land mapping</p> <p>Control of administrative services for cane delivery by zones</p> <p>Conduct risk mitigation</p> <p>Set up registration facilities</p> <p>Prepare farmer land mapping</p> <p>Communicate cane supply to farmers</p> <p>Control of the budget requirements for sugar cane receipts</p> <p>Control of labour logistics activities</p> <p>Monitor the cane receiving system to ensure smooth operation</p> <p>Set up truck queue lanes</p> <p>Preparation of cane reception facilities at the inspection post and factory</p> <p>Organise the unloading of the sugar cane in accordance with the FIFO rules</p>
	Organise cane delivery activities in each zone		
	Carry out sugarcane delivery activities		
	Organise sugarcane reception activities		
	Carry out sugarcane reception activities		

Main objective	Key function	Main function	Basic function
		Timber harvesting management (title of cultivation rights)	Find workers to cut sugar cane Set up harvesting equipment Set up sugarcane transport Supervision of the cut-load-transport process in accordance with the standards Create a milling production plan
	Dept. Production – Milling Department	Perform milling job planning	Perform division of labour Coordinate milling process implementation Evaluate the milling job plan Plan the budget to meet the needs for consumables and spare parts for the milling process
		Organise milling activities	Analyse and solve the problem *** Analysis of the milling process and the materials Determine the milling process and flow method
		Evaluate milling activities	Evaluate the parameters of the Tandem Mill, Cane Preparation according to the procedure Evaluate the unloading of sugar cane trucks according to sequence and production capacity, and check and repair the hydraulic tipping system in the Tipper Control Room according to procedure Assessment of the condition of the scraper (mini-excavator) in accordance with procedures Evaluate machinery (cutter, shredder, side cane carrier, main cane carrier) and cleanliness in the cane preparation area in the field according to procedures Field evaluation of the operation of milling machines, pumps, intermediate carriers, bagasse elevators in accordance with procedures Assessment of the condition of the existing lubricants, periodic replacement of the lubricants, cleaning of the residual grease on the tandem mill in accordance with the procedures
		Control milling activities	Control of the operation of the tandem mill, cane preparation machine Controlled sugar cane truck dumping operations according to sequence and production capacity, and checked and repaired the hydraulic tipping system in the Tipper Control Room Control operations of scraper (mini excavator) Control of machine operation (cutter, shredder, side cane carrier, main cane carrier) and cleanliness in the cane preparation area in the field Control of the operation of the milling machines, the pumps, the intermediate carriers, the bagasse elevators in the field Assessment of the condition of the available lubricants, periodic replacement of lubricants, cleaning of residual grease on the tandem mill in accordance with procedures

(Continued)

Table 6. Continued.

Main objective	Key function	Main function	Basic function
		Operate tools in the milling section	<p>Operate the Tandem Mill machine, Cane Preparation as well as checking the actual condition of the machine with virtual inspection and taking vibration, temperature data periodically in the Distribute Control System</p> <p>Check the actual condition of the tandem mill machine, cane preparation by virtual inspection and taking vibration, temperature data periodically in the field according to procedures</p> <p>Operate the sugarcane dumping truck in accordance with the sequence, production capacity and check and repair the hydraulic tipper system in the Tipper Control Room in accordance with procedures</p> <p>Check the condition of the available lubricant, change the lubricant drum, clean the remaining grease on the tandem mill in accordance with the procedure</p> <p>Clean of the rest of the sugar cane on the truck by means of a scraper (mini-excavator) in accordance with the procedure</p> <p>Monitor machinery (cutter, shredder, Side Cane Carrier, Main Cane Carrier) and cleanliness in the cane preparation area in the field in accordance with procedures</p> <p>Monitor of the milling machines, pumps, intermediate carriers and bagasse elevators in the field in accordance with the procedures</p> <p>Assessment of the condition of the available lubricants, periodic replacement of lubricants, cleaning of residual grease on the tandem mill in accordance with procedures</p>
		Perform machine maintenance in the milling section	<p>Disassembly, cleaning, inspection, repair and reassembly of cane preparation machines</p> <p>Disassembly, cleaning, inspection, repair and reassembly of intermediate support machines</p> <p>Disassemble, clean, inspect, repair and reassemble milling machines</p> <p>Coordination of machine maintenance issues in the grinding department with the engineering department related to the outside of the factory</p> <p>Create a working plan to produce ***</p>
Dept. Production – Process	Manage all production management		<p>Create a production schedule ***</p> <p>Coordinate the implementation of the production process ***</p> <p>Evaluate the production work plan ***</p> <p>Plan the budget to meet the needs of the consumables and spares process ***</p> <p>Analyse and solve the problem ***</p> <p>Perform process and material analysis ***</p> <p>Determine process method and flow ***</p> <p>Evaluate bagging machine operations ***</p> <p>Ensure that bagging machine process parameters are according to procedures ***</p> <p>Identify finished product packaging ***</p> <p>Supervise subordinates ***</p> <p>Evaluate the operation of batch centrifuges ***</p> <p>Evaluate the operation of a continuous centrifuge ***</p> <p>Evaluate the operation of rotary dryers ***</p> <p>Evaluate the operation of the fluidised drying machine ***</p> <p>Ensure that the process parameters of the dryer are in accordance with procedures ***</p>
		Organise production activities	
		Control packaging activities	
		Control of the operational activities of the centrifugal machines and the drying machines	

Main objective	Key function	Main function	Basic function
	Control the crystallisation process	Control the crystallisation process	<p>Evaluate the operation of the vacuum pan unit ***</p> <p>Ensure that the crystallisation process parameters are in accordance with the procedure ***</p> <p>Identify raw and auxiliary materials in the crystallisation process ***</p> <p>Evaluate the operation of the carbonation machine ***</p> <p>Evaluate the operation of a filter press filtration machine ***</p> <p>Evaluate the operation of the filtration machine <i>rotary leaf filter</i>***</p> <p>Evaluate ion exchange resin unit operation ***</p> <p>Control of <i>filter/strainer fine liquor</i>***</p> <p>Evaluate the operation of the evaporator unit ***</p> <p>Control of <i>filter/strainer thick liquor</i>***</p> <p>Identify the composition of raw and auxiliary materials in the carbonation process. ***</p> <p>Evaluate the operation of a weighing weighing scale unit ***</p> <p>Evaluation of the operation of the mingler machine ***</p> <p>Evaluate the operation of affinity centrifuges ***</p> <p>Evaluate the operation of the screw affination machine ***</p> <p>Evaluate the operation of the affination smelter ***</p> <p>Ensure that affination parameters are in accordance with the procedure ***</p> <p>Identify raw and auxiliary affination materials ***</p> <p>Control bagging machine operations ***</p> <p>Control of the sewing machine operations ***</p> <p>Control of bagging machine process parameters in accordance with procedures ***</p> <p>Control of the operation of batch type centrifuges ***</p> <p>Control of the operation of a continuous centrifugal machine ***</p> <p>Control of the operation of the rotary dryer unit ***</p> <p>Control of the operation of the fluidised bed drying unit ***</p> <p>Control of evaporator operation ***</p> <p>Control of a thick liquor strainer/filter ***</p> <p>Control of vacuum pan operations ***</p> <p>Control of receiver tank operation ***</p> <p>Control of the use of raw materials and auxiliary materials used in the crystallisation process ***</p>
	Control the purification process	Control the purification process	<p>Control the operation of weighing units ***</p> <p>Control the mingler machine operations ***</p> <p>Control the operation of affination centrifuges ***</p> <p>Control the operations of the affination screw unit ***</p> <p>Control the operation of the carbonation unit ***</p> <p>Control the operation of the filter press filtration unit ***</p> <p>Control the operation of the rotary leaf filter filtration unit ***</p> <p>Control operations of <i>ion exchange resin column</i>***</p> <p>Control <i>filter/strainer fine liquor</i>***</p> <p>Operate the bagging machine ***</p> <p>Operate the sewing machine ***</p> <p>Operate the rotary drying machine ***</p> <p>Operate the fluidised drying machine ***</p> <p>Operate batch-type centrifugal machines ***</p> <p>Operate continuous type centrifugal machine ***</p> <p>Operate the vacuum pan ***</p> <p>Control the tank receiver ***</p>
	Control activities packaging	Control activities packaging	
	Control the operation of centrifuges and dryers	Control the operation of centrifuges and dryers	
	Process control Crystallisation	Process control Crystallisation	
	Control the process of Affinity	Control the process of Affinity	
	Operate tools in the bagging section	Operate tools in the bagging section	
	Operate tools in the drying section	Operate tools in the drying section	
	Operate tools in the centrifugation section	Operate tools in the centrifugation section	
	Operate tools in the crystallisation section	Operate tools in the crystallisation section	

(Continued)

Main objective	Key function	Main function	Basic function
		Operate tools in the evaporation section	Operate the evaporator unit ***
		Operate tools in the decolourisation section	Operate a liquor filter/strainer ***
		Operate tools in the purification section	Operate the ion exchange resin machine ***
			Operate the carbonator unit ***
			Operate the filter press filtration machine ***
			Operate rotary leaf filter filtration machine ***
		Operate tools in the affination section	Operate the mingler machine ***
			Operate the affination centrifuge ***
			Operate the screw affination machine ***
			Operate the melter machine ***

Notes:

*This is the basic function of the Decree of the Minister of Manpower of the Republic of Indonesia No. 200 of 2016 on the Determination of Indonesian National Competency Standards for Professional, Scientific and Technical Services Category Principal Group of Other Professional, Scientific and Technical Services in the Field of Chemical Analysis.

**This is the basic function of the adoption of the Decree of the Minister of Manpower of the Republic of Indonesia No. 216 of 2017 on the Determination of the Indonesian National Work Competency Standards for the Category of Professional, Scientific and Technical Activities of the Principal Group of Architectural Activities and Engineering; Analysis and Technical Tests in the Field of Chemical Analysis Sub-sector of Bioassay and Analysis Related to Food Halal Safety.

***This is the basic function of the adoption of the Decree of the Minister of Manpower of the Republic of Indonesia No. 178 of 2020 on the Determination of the Indonesian National Work Competency Standards for the Processing Industry Category of the Food Industry Principal Group in the Refined Crystal Sugar Industry in the Quality Control and Production Sub-Sector (Ketenagakerjaan, 2020).

Table 7. List of cut-load-transport and milling units of competence.

No	Unit code	Title of competency unit
1.	C.10GKP00.001.1	Plan for cut-load-transport activities
2.	C.10GKP00.002.1	Coordination of the implementation of the cut-load-transport activities
3.	C.10GKP00.003.1	Plan of the budget for the activities of the cut-load-transport
4.	C.10GKP00.004.1	Plan the target of cut-load-transport activities
5.	C.10GKP00.005.1	Analyse cut-load-transport problems and their solutions
6.	C.10GKP00.006.1	Prepare the cut-load-transport budget plan
7.	C.10GKP00.007.1	Set up targets for cut-load-transport activities
8.	C.10GKP00.008.1	Prepare a risk mitigation plan for cut-load-transport activities
9.	C.10GKP00.009.1	Coordination of cut-load-transport activities
10.	C.10GKP00.010.1	Evaluate the cut-load-transport activities
11.	C.10GKP00.011.1	Plan operator tasks and targets for each zone
12.	C.10GKP00.012.1	Control of farmer registration
13.	C.10GKP00.013.1	Control of farmer land mapping
14.	C.10GKP00.014.1	Control of administrative services for cane delivery by zones
15.	C.10GKP00.015.1	Perform risk mitigation
16.	C.10GKP00.016.1	Set up registration facilities
17.	C.10GKP00.017.1	Prepare farmer land mapping
18.	C.10GKP00.018.1	Communicate sugarcane supply with farmers
19.	C.10GKP00.019.1	Control of cane revenue budget requirements
20.	C.10GKP00.020.1	Control of labour logistics activities
21.	C.10GKP00.021.1	Monitor the cane receiving system to ensure smooth operation
22.	C.10GKP00.022.1	Set up truck queue lanes
23.	C.10GKP00.023.1	Prepare the means of receiving sugarcane at the monitoring post and factory
24.	C.10GKP00.024.1	Organise the unloading of sugarcane in accordance with FIFO rules
25.	C.10GKP00.025.1	Find workers to cut sugar cane
26.	C.10GKP00.026.1	Prepare harvesting equipment
27.	C.10GKP00.027.1	Set up sugar cane transport
28.	C.10GKP00.028.1	Supervise the cut-load-transport process according to standards
29.	C.10GKP00.029.1	Create a milling production plan
30.	C.10GKP00.030.1	Perform division of labour
31.	C.10GKP00.031.1	Coordinate milling process implementation
32.	C.10GKP00.032.1	Evaluate the milling job plan
33.	C.10GKP00.033.1	Plan the budget to meet the needs for consumables and spare parts for the grinding process
34.	C.10GKP00.034.1	Analyse milling problems and their solutions
35.	C.10GKP00.035.1	Analyse the grinding process and materials
36.	C.10GKP00.037.1	Evaluate Tandem Mill, Cane Preparation parameters according to procedure
37.	C.10GKP00.038.1	Evaluate the unloading of sugar cane trucks according to sequence and production capacity, and check and repair the hydraulic tipping system in the Tipper Control Room according to procedure
38.	C.10GKP00.039.1	Evaluate the condition of the scraper (mini-excavator) according to the following procedures
39.	C.10GKP00.040.1	Evaluate machinery (cutter, shredder, side cane carrier, main cane carrier) and cleanliness in the cane preparation area in the field according to procedures.
40.	C.10GKP00.041.1	Evaluate the operation of milling machines, pumps, intermediate carriers, bagasse elevators in the field according to procedures.
41.	C.10GKP00.042.1	Evaluate the condition of existing lubricants, periodically replace lubricants, clean residual grease from the tandem mill according to procedures.
42.	C.10GKP00.043.1	Control of the operation of the tandem mill, cane preparation machine
43.	C.10GKP00.044.1	Control of the sugar cane truck dumping operations according to sequence and production capacity, and checked and repaired the hydraulic tipping system in the Tipper Control Room.
44.	C.10GKP00.045.1	Control of the operations scraper (mini excavator)
45.	C.10GKP00.046.1	Control of machine operation (cutter, shredder, side cane carrier, main cane carrier) and cleanliness in the cane preparation area in the field.
46.	C.10GKP00.047.1	Control of the operation of milling machines, pumps, intermediate carriers, bagasse elevators in the field
47.	C.10GKP00.048.1	Operation of the tandem mill machine, cane preparation, as well as checking the actual condition of the machine with virtual inspection and recording vibration and temperature data periodically in the Distribute Control System
48.	C.10GKP00.049.1	Check the actual condition of the Tandem Mill machine, Cane Preparation by virtual inspection and taking vibration, temperature data periodically in the field in accordance with procedures
49.	C.10GKP00.050.1	Operate the sugar cane dump truck in accordance with the sequence and production capacity, and check and repair the hydraulic dump system in the dump truck control room in accordance with procedures
50.	C.10GKP00.051.1	Check the condition of the available lubricant, replace the lubricant drum, clean the remaining grease on the tandem mill according to the procedure
51.	C.10GKP00.052.1	Clean the remaining sugar cane on the truck using a scraper (mini-excavator) according to procedures.
52.	C.10GKP00.053.1	Monitor the machinery (cutter, shredder, side cane carrier, main cane carrier) and cleanliness of the cane preparation area in the field according to procedures.
53.	C.10GKP00.054.1	Monitor milling machines, pumps, intermediate carriers, bagasse elevators in the field according to procedures
54.	C.10GKP00.055.1	Disassemble, clean, inspection, repair and reassemble of cane preparation machines
55.	C.10GKP00.056.1	Disassemble, clean, inspection, repair and reassemble of intermediate support machines
56.	C.10GKP00.057.1	Disassemble, clean, inspect, repair and reassemble milling machines
57.	C.10GKP00.058.1	Coordination of machine maintenance issues in the grinding department with the engineering department related to the outside of the factory.

of competence into a national standard where several sugar cane factories are needed to make the mapping of competency units into national standards for the white crystal sugar sector. The draft competency map for the white crystal sugar field is a comprehensive description of the competencies of each function in a business field that is used as a reference in compiling competency standards.

This competency mapping can be used by organisations as an employee assessment tool, allowing them to maximise the potential of employees by assigning them to tasks with the highest probability of success. In addition, the information can be used to focus talent on relevant tasks and to draw on employees' expertise. As a result, organisations are likely to see results such as increased productivity and improved profits. Companies or sugar factories can also use competency mapping to write thorough job descriptions and attract talented people with the right skills. In addition, competency mapping can boost morale by outlining expectations and ensuring that employees understand how to achieve a good result. Employees may find it easier to gain the support of their employer if both parties are aware of the expectations. In addition, the transparency created by competency mapping facilitates career development. Building industry-relevant skills will encourage innovation and prepare employees for more advanced positions within the organisation.

5. Conclusions and suggestions

5.1. Conclusions

The results of the evaluation of the sugar production process technology using the non-numerical multi-expert multi-criteria decision-making method on two different objects have the same result that the cut-load-transport section is a priority that requires new technology. This is because Indonesia's sugarcane area is 449 hectares in 2022, with the largest composition of 59% smallholder plantations, 30% large private plantations and 11% large state plantations. As a result, the majority of cane harvesting activities is carried out by farmers using manual equipment rather than mechanisation.

Various considerations in the design of competency unit mapping are by evaluating sugar production process technology and identifying related Indonesian national competency standards. The design of this competency unit map can also be used by internal sugar factories that are the subject of research as well as an initial design for the white crystal sugar industry to continue as a competency unit in a national standard where several sugar cane factories are needed to make the mapping of competency units in national standards for the field of white crystal sugar.

5.2. Suggestions

The role of stakeholders in the availability of competency infrastructure, one of which is national work competency standards, is needed and can be used as a government programme to facilitate and other parties support by participating according to their respective roles. Further research of this study is to look for the effect of the relationship between competency infrastructure and cane sugar productivity.

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Author's contributions

Conceived and designed the experiments: Alex Denni, Illah Sailah & M. Marimin; performed the experiments: Illah Sailah & M. Mursiti; analysed and interpreted the data: Illah Sailah, M. Marimin, M. Romli & M. Mursiti; contributed reagents, materials, analysis tools or data: M. Marimin, Alex Denni & M. Mursiti; wrote the paper: Illah Sailah, M. Marimin, M. Romli & M. Mursiti.

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Data availability

The data that support the findings of this study are available on request from the corresponding author upon reasonable request.

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