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The influence of green ergonomic factors on physical environmental conditions and fish smoking processing efficiency

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ABSTRACT

Several studies have been carried out related to fish smoking processing centers that have caused environmental problems, but none have linked the green ergonomics factor as a solution to these problems. The purpose of this study was to determine the relationship between the influence of ergonomic factors on physical environmental conditions and processing efficiency at the Fish Smoking Center of Plaza Ikan Karangsari Tuban. This study used the PLS-SEM analysis technique to describe the relationship between the influence of green ergonomic factors on physical environmental conditions and processing efficiency. The data were analyzed using the SmartPLS technique to evaluate the measurement model and structural model. According to the data analysis, it was found that at Plaza Ikan Karangsari Tuban, the ergonomic factors do not have significant effect on processing efficiency with a statistical t value of 0.422. The ergonomic factors have a significant effect on the work environment with a t statistic of 5.305 and processing efficiency with a t statistic of 2.608. Thus, it can be concluded that the green ergonomic factors in the fish smoking center at Karangsari Tuban do not have significant effect on processing efficiency and have a significant effect on physical working environment conditions.

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INTRODUCTION

Green ergonomics is risk reduction, environmental awareness, community involvement and cultural support for everyone in the company (Pilczuk & Barefield, 2014). Ergonomics or human factors is the study of human relationships and other elements of a system which they have interaction in the workplace and apply relevant theories, principles, data and methods to optimize system performance while maximizing human well-being (IEA, 2015). Green ergonomics recognizes a two-way relationship with the natural environment; humans affect the health of their natural environment and the health of the natural environment, which in turn has an effect on human health and well-being, including humans and their economic and social development needs

(Thatcher, 2013). Green ergonomics involves the effect of human systems on ecosystems reduction through ergonomic design to avoid or mitigate natural crises (Thatcher, 2013). Green ergonomics includes the principles of eco-efficiency, eco-effectivity and eco-productivity (Thatcher, 2013).

Most areas in Indonesia have territorial waters; therefore, marine products in the form of fish in Indonesia are abundant (Dzaki1 et al., 2015). East Java is one of the largest suppliers of fishery products in Indonesia; one of a district with considerable fishery potential is Tuban (Nurdiani et al., 2020). Fish contain a source of protein that humans need, but because of their high-water content, fish are easily rotten (Domili & Febriyanti, 2018). Thus, preservation is needed, one of which is by smoking. To keep the quality of fish, preservation processes such as drying, salting, and smoking are needed (Sirait & Saputra, 2020). Some of the advantages of smoked fish include its ability to develop a delicious aroma, brown or black color, good texture, and a unique and delicious taste (Kaban et al., 2019). Preservation of fish by smoking can be done with equipment that is simple, easy to obtain and the price is cheap (Darianto, 2019). However, the fish smoking process generally produces waste leading to environmental pollution. The use of simple equipment and the lack of sanitation and hygiene aspects have an effect on health and the environment (Shoimah et al., 2013).

Tuban has a center for selling fish products, namely Plaza Ikan, which is located in Karangsari, Tuban. Generally, smoking fish in Karangsari uses coconut shell fuel. Coconut shell as a source of smoke has advantages such as its easy availability and by-products that can be utilized optimally (Suradi et al., 2011). Fish smoking in Karangsari takes place at home, so that production and household activities are mixed and it causes various environmental problems (Santri & Putri, 2020). The possibility of fish smoking is mentioned as a source of pollution that local people complain about because many of its activities are thought to have an effect on environmental degradation (Shoimah et al., 2013).

Several studies of environmental pollution on the effect of fish smoking have been carried out by Dzaki et al. (2015) and Jannah (2019) regarding the fish smoking industry in Bandarharjo Village that causes environmental pollution, one of which is air pollution, health problems, and housing discomfort. Tulandi & Handriyono (2019) stated that the fish smoking in Tambak Wedi Surabaya contributes to CO gas emissions that cause an air quality decrease. Wonosari fish smoking center causes environmental problems (Shoimah et al., 2013). The fish smoking process in Sumurgung, Tuban Regency has the potential of air pollution (Awaludin Prihanto et al., 2020).

Regarding environmental pollution, the effect of fish smoking also occurred at Fish Plaza area in Karangsari - Tuban. Based on this fact, the problem arises how environmental pollution affects fish smoking in the fish plaza area of Karangsari Tuban in terms of a green ergonomic perspective. The ergonomic approach provides insight into the sustainable relationship between humans and ecology in facilitating human well-being by considering the overall performance of the socio-ecological system. To answer this question, it is detailed in the form of research questions as follows: (1.) How is green ergonomics related to physical environmental conditions? (2.) How is green ergonomics related to processing efficiency? (3.) How is physical environmental conditions related to processing efficiency? Thus, the purpose of this study was to describe the relationship between physical environmental conditions, processing efficiency and green ergonomics of fish smoking in Karangsari with the expectation of changing in human behavior and realizing better collaboration.

Literature Review

Green Ergonomic

Green ergonomics is defined as the well-being of human and natural systems through understanding the two-way relationship between natural and human systems (Thatcher, 2013).

Zink (2014) stated that theoretically there are three pillars of acceptable sustainability (i.e. economic, ecological and social objectives) that have became part of traditional ergonomics. Natural systems provide ecological services that provide food and resources that enable the human well-being and health, whereas humans need a conservation ethic to ensure the preservation and restoration of the natural environment (Lange-Morales et al., 2014). From a green ergonomics perspective, when the natural environment becomes degraded and depleted there can be no human well-being sustainable and effectiveness (Lange-Morales et al., 2014). The ultimate goal of green ergonomics is to ensure that there is mutual benefit between human systems and natural systems, to provide support for both sets of systems so that they can continue indefinitely into the future (Lange-Morales et al., 2014). The application of ergonomics can also help to ensure that equipment, products and systems are designed appropriately so as to reduce waste related with inefficiency or rejection (Hanson, 2013).

Physical Work Environment

The physical work environment is a physical condition around the workplace that can directly or indirectly affects employees (Panjaitan, Maludin, 2017). A good work environment affects employee productivity. One of the indicators to measure work productivity is efficiency (Sutrisno, 2011). A company's work environment affects employee productivity (Panjaitan, Maludin, 2017). The incompatibility of the work environment causes employees to be unable to work effectively and efficiently (Peoni, 2014). By coordinating the work and work environment with people or vice versa, an ergonomic work environment can be created for productivity (Listiani, 2010)

Processing Efficiency

Efficiency is a level measure of resources used in a process. The fewer resources used, the more efficient the process. An efficient process is characterized by process improvement so that it becomes cheaper and faster (Sedarmayanti, 2014). Efficiency is an environmental performance increase of a product through the selection of low-impact materials, reduction of material use, reduction of energy consumption, reduction of waste and pollution of the functional unit of the product during its life cycle (Jakobsen, 1999).

For these reasons, it is hypothesized that: (1) Green ergonomics affects the physical working environment, (2) Green ergonomics affects processing efficiency, (3) Physical work environment affects processing efficiency.

RESEARCH METHODS

Research Design

This study used the PLS-SEM analysis technique because it is a comprehensive multivariate statistical analysis approach that can simultaneously examine every relationship between variables in the conceptual model, including measurement and structural components. This study aimed to explain the effect of green ergonomics on physical environmental conditions and processing efficiency in the form of numbers with a literature study to strengthen the analysis. The sampling used was purposive sampling technique. Three questionnaires were distributed to examine the relationship between the three items, namely the green ergonomics factors, physical environmental conditions and processing efficiency. Each questionnaire sheet contained 7 items. The three data were developed with the following research model.

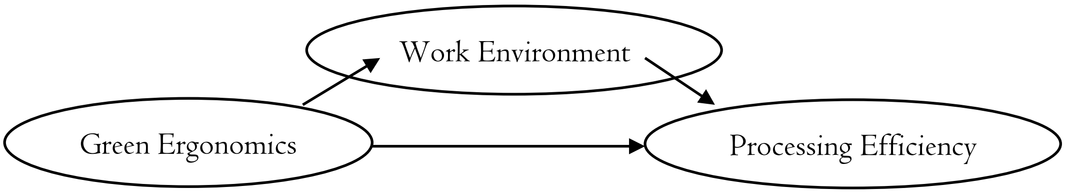

Figure 1. Model of Study

The study location is in Karangsari Village, Tuban District, Tuban Regency. The time of the study took place during April 2022. The map of the study location is shown in Figure 2.

Figure 2. Location Map of Karangsari - Tuban

Population and Samples

The population in this study was all smoking fish workers in Karangsari Tuban. The sample used was 40 workers who were taken using a random purposive sampling method, which was done by taking samples from the population based on random certain criteria (Sugiyono, 2010).

Instruments

The instrument used in this study was a questionnaire sheet with the answers to each instrument item using a Likert scale in the form of choices ranging from 1 = "strongly disagree" to 5 = "strongly agree". The questionnaire sheet consisted of sheets of green ergonomics factors, physical environmental conditions, and efficiency of material use. Green ergonomics factor questionnaire was given to workers containing the factors that make up green ergonomics. The physical work environment questionnaire sheet was modified from Sedarmayanti (2011) which was developed into seven indicators. The questionnaire sheet for the use efficiency of raw materials was modified from Subari et al. (2012). The efficiency of using raw materials was analyzed based on the ability of fish smoking activities to use materials efficiently which was reviewed from the use of raw materials, product results obtained by recycling, waste control, and rejection. Each category of questionnaire contained 7 indicator items.

Table 1. Physical Work Environment Questionnaire

No.	Variable
1.	The space lighting in the fish smoking environment has met the standard. (bright but not dazzling)
2.	The environment temperature around fish smoking is normal.
3.	The environment humidity around fish smoking is standard, not too hot, and humidity is low.
4.	The air circulation in the environment around fish smoking is clean, oxygen levels are not reduced and do not mix with harmful gases.
5.	The noise level in the environment around the fish smoking is low. Rarely heard sounds that are not desired by the ear.
6.	The road conditions in the environment around the fish smoking are good, not muddy and dusty.
7.	The garbage dumps in the environment around fish smoking have met the standard.

Table 2. Efficiency Questionnaire

No.	Variable
1.	The fish smoking industry is able to utilize raw materials efficiently with supervision and planning that can reduce the use of raw materials.
2.	The fish smoking industry is able to increase product results by recycling, controlling waste, and reducing failed products.
3.	The fish smoking industry monitors the amount of solid waste and manages it so that resource utilization can be wider.
4.	The fish smoking industry is able to store materials safely, manage toxic hazardous materials, and manage packaging.
5.	The fish smoking industry is able to use water well by saving water and managing liquid waste so that it does not pollute the environment.
6.	The fish smoking industry is able to control energy use by controlling the production process.
7.	The fish smoking industry is able to reduce the risk of accidents and occupational health by monitoring and securing it.

Table 3. Green Ergonomics Forming Factors Questionnaire

No.	Statements
1.	I use renewable energy as fuel in the fish smoking process
2.	I recycle fish smoking waste
3.	I have been doing activities that can have an effect on environmental change
4.	I use environmentally friendly materials in the process of fish smoking
5.	I throw the fish smoking waste into the garbage bin
6.	I sort fish smoking waste for recycling
7.	I separate home activities and work activities

Procedures

The procedure of this study consisted of two stages, namely the study preparation stage and the study implementation stage. The study preparation stage was carried out before the beginning of the study. The step taken was literature reviewed (textbooks, journals and other reading sources) related to the study. In addition, observations were made to the research site to determine the the physical environment conditions and the use of materials efficiency. Furthermore, the researchers made a research instrument in the form of a questionnaire sheet. The study implementation stage was conducted by observing the process of fish smoking in Karangsari Tuban. The observation process is carried out by observing the physical work environment conditions and the raw materials efficiency. Then, the distribution of questionnaires was carried out to obtain workers' perceptions of the factors forming green ergonomics.

Data Analysis

This study used the PLS-SEM analysis technique because it is a comprehensive multivariate statistical analysis approach that can examine the relationship between variables in the conceptual model, including measurement and structural components (Hair et al., 2019). This study used SmartPLS 3.2.7 software. Following the PLS-SEM literature analysis, a two-step approach was taken, namely evaluating the measurement model and structural model (Hair et al., 2019). The measurement model was assessed by evaluating the reliability and validity of the reflective construct, while the structural model was assessed by assessing R2, f2, Q2 and path coefficients (Hair et al., 2019).

RESULT

Measurement Model

The reliability of the measurement scale for each construct was analyzed before evaluating the measurement model. To assess the reliability of each item, the loading of indicators with each construct was examined. The outer loading value must be greater than 0.708 (Hair et al., 2019). Therefore, it is necessary to verify the results of the other measurement indices for the constructs of these items (Hair et al., 2019). Each construct originally contained 7 indicators and each item would be deleted one by one if there were indicators that did not reflect the variable so that their indicators that truly reflected variables were indicated by the outer loading value greater than 0.708. Table 4 shows the value of outer loading on the construct of each instrument. To assess the individual reliability of each construct, composite reliability (CR) was calculated. The CR value was greater than 0.7 for all composites (Jum C Nunnally; Ira H Bernstein, 1994). Table 4 shows the value of reliability and validity. After analyzing the reliability, the convergent validity was reviewed with the Average Variance Extracted (AVE), which should be greater than 0.5 (Fornell & Larcker, 1981). The calculation results show that all AVEs for each construct are greater than 0.5.

Structural Model

Before analyzing the structural relationship, collinearity should be checked to ensure that there is no bias in the regression results. Ideally, the value of the variance inflation factor (VIF) should be lower than 3 (Hair et al., 2019). In this study, there was no collinearity problem because the VIF value was below the specified limit (Table 6). The next test step is to assess the structural model. PLS-SEM is a nonparametric method and therefore, bootstrap was used to determine statistical significance (Chin, 1998). The bootstrap procedure using 2,000 iterations used to evaluate the significance of the indicators and the path coefficients.

Table 4. Measurement Model Results

Construct/Item	Loading	Composite Reliability	Average Variance Extracted (AVE)
Green Ergonomic Factors		0.882	0.789
I throw the fish smoking waste into the garbage bin	0.951		
I separate home activities and work activities	0.821		
Physical Working Environment Condition			0.600
The air circulation in the environment around smoking fish is clean, oxygen levels are not reduced and do not mix with harmful gases	0.830	0.818	
The noise level in the environment around the fish smoking is low. Rarely heard sounds that are not wanted by the ear	0.733		
The garbage disposal in the environment around the fish smoking has met the standard	0.758		
Processing Efficiency			
The fish smoking industry is able to utilize raw materials efficiently with supervision and planning that can reduce the use of raw materials	0.801	0.795	0.564
The fish smoking industry monitors the amount of solid waste and manages it so that resource utilization can be wider	0.725		
The fish smoking industry is able to use water well by saving water and managing liquid waste so that it does not pollute the environment	0.724		

Table 5. Discriminant validity value

		Efficiency	Ergonomic Factors	Work Environment
Fornell–Larcker	Efficiency	0.751		
	Ergonomic Factors	0.371	0.888	
	Work Environment	0.528	0.607	0.775
Heterotrait-monotrait (HTMT)	Efficiency			
	Ergonomic Factors	0.461		
	Work Environment	0.800	0.801	

Table 6. Structural Model Evaluation

Relation	Variance explained (R^2)	R^2 adjusted	Predictive Relevance (Q^2)	Effect size (f^2)	VIF
Ergonomic Factors → Processing Efficiency	0.283	0.244	0.114	0.006	1.583
Ergonomic Factors → Work Environment	0.368	0.352	0.200	0.583	1.000
Ergonomic Factors → Processing Efficiency				0.202	1.583

Table 7. Path Coefficient

Relation	Original Sample (O)	Sample Mean (M)	Standart Deviation (STDEV)	T statistics
Ergonomic Factors → Processing Efficiency	0.081	0.091	0.191	0.422
Ergonomic Factors → Work Environment	0.607	0.615	0.114	5.305
Ergonomic Factors → Processing Efficiency	0.479	0.489	0.184	2.608

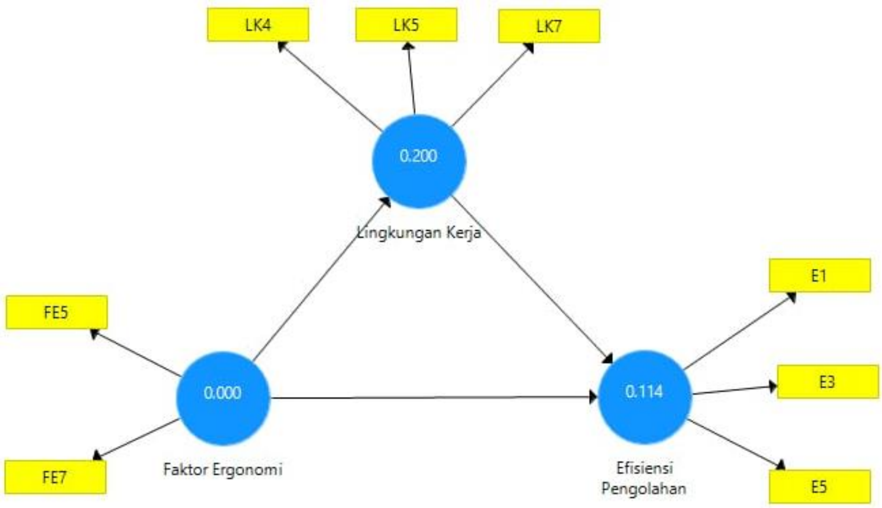

Figure 3. Model Results.

DISCUSSION

Reliability and validity were analyzed first in the measurement model. The reliability of the measurement scale for each construct was analyzed by looking at the outer loading value that must be more than 0.708 (Hair et al., 2019). Then, the calculated Composite Reliability (CR) value must be more than 0.7 (Fri C Nunnally; Ira H Bernstein, 1994). In Table 4 we can see that the loading value and the Composite Reliability (CR) value. For each construct, we can see in Table 4 that the outer loading value is more than 0.708. Composite Reliability Values for green ergonomic factors (0.882), physical working environment conditions (0.818), and processing efficiency (0.795). The three variables have a CR value of more than 0.7. After that, the convergent validity was reviewed with the Average Variance Extracted (AVE) that must be greater than 0.5 (Fornell & Larcker, 1981). Table 4 shows the AVE value for each variable; they are the green ergonomics factor (0.789), physical environmental conditions (0.600), and processing efficiency (0.564). The three variables show an AVE value are bigger than 0.5. So, the measurement scale has met the reliability and validity.

Then, the significance of each loading was determined by using the bootstrap resampling procedure (2,000 subsamples from the original sample size) to obtain the t statistic value (Hair, 2016). The results show that all loadings were obtained significantly with a confidence level of 99.9%. The next step is discriminant validity analysis using Fornell Larcker criteria. The square root of each value of the AVE construct must be higher than the correlation construct with other latent variables (Fornell & Larcker, 1981). The results show that the value of the AVE construct is higher. In this study, the values obtained remained below the limit values indicating good evidence of reliability and validity (Table 5).

Before testing the hypothesis, a quality assessment of the model was carried out. The criteria used are the coefficient of determination (R2), effect size (f2), cross-validated redundancy (Q2), and path coefficient (Hair et al., 2019). R2 measures 0.75, 0.50 and 0.25 for all endogenous structures, considered to be substantial, moderate, and weak (Hair et al., 2019). In the structural relationship analysis, Table 5 shows that the VIF value is below the set limit so that there is no regression bias problem. The result of R2 on the processing efficiency is 0.283 and R2 in the working environment is 0.368. This shows that each of these variables is influenced by exogenous variables with moderate criteria.

The effect size for each path model can be determined by calculating f2 with the criteria of 0.02 (small), 0.15 (medium) and 0.35 (large) (Hair et al., 2019). On the perceived effect of processing efficiency, only the working environment (0.202) affected by moderate criteria. Meanwhile, the green ergonomics factor (0.006) has a small effect. On the perceived effect of the work environment, the green ergonomics factor (0.583) has a large effect. The results of the model can be seen in Figure 3.

Finally, to conclude the evaluation of the structural model, the current study examined the predictive relevance of the model using Stone-Geisser's Q2 (Hair et al., 2019). The results show that all Q2 values are above zero (Table 6), which indicates that the model has acceptable predictive power.

Ghozali (2009) argues that the significant hypothesis is seen from the Path Coefficients table. In this study, the value of t count is smaller than t table 1.96 (Table 7). The path coefficient value for the influence of ergonomic factors on processing efficiency is 0.422 which is below 1.96. So it can be concluded that ergonomic factors have no significant effect on processing efficiency. With the path coefficient value of 0.081 which is positive, it can be interpreted that an increase in the green ergonomics factor will increase processing efficiency and vice versa. However, because the results of data analysis show no significant relationship, it can be said that the increase and decrease in ergonomic factors do not affect the increase and decrease in processing efficiency.

Meanwhile, the path coefficient value for the direct influence of ergonomic factors on the work environment shows the t statistic value of 5.305 which is above 1.96. So it can be stated that ergonomic factors have a significant effect on the work environment. The path coefficient value is 0.607 which is positive, so the increase and decrease in ergonomics factors affect the increase and decrease in the work environment. It means that the green ergonomics factor from workers can affect the work environment. Thus, to improve the quality of the work environment, a good green ergonomics factor is needed.

The path coefficient value for the effect of the work environment on processing efficiency is 2.608 (it is bigger than 1.96). So, it can be stated that work environment factors have a significant effect on processing efficiency. The path coefficient value is 0.479 (positive numbers), it means that a higher increase in a work environment will also increase processing efficiency. Likewise, if the work environment is lower, it will cause processing efficiency to decrease. This is in line with the study of Panjaitan and Maludin in 2017 that reveals there is a positive and significant effect of the work environment on work productivity, including efficiency. Ergonomics can stand in a paradoxical position in achieving its goals in terms of design and efficiency (Dekker et al., 2013). A conducive work environment produces optimal work productivity (Ayunasrah & Diana, 2022). Green ergonomics works on the concepts of eco-efficiency and eco-productivity (Lange-Morales et al., 2014).

Thus, because the results of the study show that green ergonomics has a significant effect on the work environment and the work environment has a significant effect on processing efficiency. So, by improving the ergonomics of workers around the fish processing center, it will overcome the existing environmental problems. Various discussions on various environmental problems globally are associated with ergonomic solutions (Mikulčić et al., 2020). With a high green ergonomics factor, it will have an effect on improving the quality of the work environment; an increase work environment will increase processing efficiency. High efficiency can have an effect on environmental sustainability. In accordance with the study of Thatcher (2013) proposes that ergonomics must overcome the problems of water and food shortages, inefficient use of energy, pollution and waste, and rapid urbanization. Ergonomists must be able to overcome "global environmental and social problems, such as pollution from big cities". Policies for behavior change are the main factors for realizing green ergonomics (Moengin et al., 2021). Employee participation for sustainability can be contributed through the application of ergonomics (Bolis et al., 2014).

Regarding the sustainability of natural and human systems, workers should consider more about their behavior to apply green ergonomics. All parties play an important role in this, especially industry players. The government can encourage innovation and new work practices in friendly environment industries so as to reduce pollution. Regular interaction by policy makers with industry to highlight ergonomic issues can encourage industry to modify technology and work practices to reduce potential environmental pollution (Poon et al., 2016). Then, society should be encouraged and sensitized to environmental pollution to ensure proper consumer behavior in waste disposal. Community involvement in behavior by applying ergonomic factors is important. Work activities and daily activities should be separated to reduce pollution. Production disposal and household waste are minimized with effective waste collection services; local authorities can allocate budgets to improve the waste collection system. It is very important to educate and encourage appropriate behavior change for sustainability.

CONCLUSION

There is a positive but not significant relationship between green ergonomics and processing efficiency. Then there is a positive and significant relationship between the green ergonomics factor and the work environment. Meanwhile, the relationship between work environment and processing efficiency shows a positive and significant relationship. The results of the three variables have a positive relationship. The green ergonomics factor does not have a significant effect on processing efficiency, but it has a significant effect on the work environment. Meanwhile, the work environment affects processing efficiency. From the results of this study, it is recommended to practice several policy implications according to priorities as input for other entrepreneurs. By increasing the green ergonomics factor, it will have an effect on improving the work environment; an increase work environment will increase processing efficiency. High efficiency can have an impact on environmental sustainability.

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