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INTEGRATING ERGONOMICS AND SUSTAINABILITY: A LITERATURE ANALYSIS USING SYSTEMATIC REVIEWS AND META ANALYSIS (PRISMA)

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Abstract:

Sustainable Development (SD) balances economic, social, and environmental pillars, currently monitored through the United Nations' 17 Sustainable Development Goals (SDGs). Achieving these global targets requires multidisciplinary approaches, notably ergonomics, which enhances human well-being and overall system performance. However, a comprehensive synthesis mapping how specific ergonomic domains integrate into broader sustainability practices remains scarce. This paper presents a systematic literature review investigating the integration of ergonomics and sustainability, structured around the International Ergonomics Association (IEA) classifications: physical, cognitive, and organizational ergonomics. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, a rigorous literature search was executed across Elsevier, Scopus, and Google Scholar databases using targeted keyword. Out of 550 initially identified articles, 100 papers were excluded due to obsolescence or irrelevance. A critical evaluation of the remaining repository narrowed the selection down to 44 highly suitable articles. Within this refined core, 13 papers explicitly developed integrated frameworks addressing sustainable product manufacturing, corporate sustainability policies, and social sustainability frameworks. This study contributes to the literature by demonstrating how physical, cognitive, and organizational ergonomic interventions directly optimize worker performance while simultaneously reducing negative environmental impacts. The findings offer a novel framework for stakeholders to

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incorporate human-centric factors into global sustainability practices, proving that protecting workforce well-being is vital for long-term sustainable development.

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Keyword:

Ergonomics, Indicators, Integrating Framework, SDGs, Sustainability

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Introduction

Sustainable development goals (SDGs) are a very important issue and a major target in achieving development globally. The SDGs encourage broader development cooperation among stakeholders, both at the local and national levels. This includes intergovernmental cooperation, funding, capacity building, human resources, technology transfer and market access. The SDGs can be used as indicators and measures of progress towards achieving sustainable development (SD) and represent the needs of stakeholders at the global level that balance economic, social, and environmental development (Fonseca and Carvalho, 2019). The SDGs comprise 17 objectives that mean to end neediness, safeguard the climate, and guarantee that all individuals can live in harmony and flourishing (Allen et al., 2019; Delli Paoli & Addeo, 2019). To achieve these SDGs, several approaches can be applied, one of which is the ergonomics approach. Ergonomics is related to understanding the interaction between humans, materials, and machines in a system, by assigning principles, theories, data, and design methods to improve human aspects and overall system performance (Iridiastadi & Yassierli, 2014) . Ergonomics increases productivity and work improvement and develops positive human values such as increased protection, improved quality of life, minimized fatigue, and stress (Chung and Williamson, 2018). For example, ergonomics can contribute to achieving several SDGs, such as SDG 3 (i.e., good health and well-being), SDG 8 (i.e., decent work and economic growth), and SDG 9 (i.e., industry, innovation, and infrastructure) (Fayomi et al., 2021). Ergonomics is related to economic sustainability in optimizing working conditions and ergonomic working environments through increased productivity and production efficiency. Ergonomics helps reduce the likelihood of injuries or accidents, turnover rates, and production losses (Haslam and Waterson, 2013; Sohrabi, 2021). Ergonomics has a strong relationship with social sustainability because it has the same goal of human health and well-being (Lee et al., 2019). Ergonomics can improve employee health and safety in the workplace by designing workplaces and equipment that are comfortable and safe to use (Papetti et al., 2020).

Ergonomics can also improve worker productivity, workplace efficiency, satisfaction, and employee morale (Sohrabi, 2021). Ergonomics helps reduce waste through waste management so that it has added value, energy consumption, and emissions by optimizing work processes and reducing unnecessary movements in product design activities so that raw materials can be used efficiently (Iqbal et al., 2024; Lin et al., 2021). Ergonomics and environmental sustainability are two important aspects of SD because they aim for environmental sustainability. Ergonomics is related to designing work environments or products according to human needs. Environment sustainability is related to maintaining and protecting the natural environment for a sustainable future, minimizing waste, preventing land degradation, minimizing water and air pollution, and protecting ecosystems and biodiversity (Norton et al., 2021; Vaish et al., 2019). The International Ergonomic Association (IEA), states that ergonomics can contribute to SD (Radjiyev et al., 2015). To optimize the well-being and performance of humans and systems, humans must be reasoned at all levels, involving physical, perceptual, mental, close to home, social, authoritative, administrative, ecological, and political (Karwowski, 2005). The relation between ergonomics and sustainability can be found in two different ways. Some research stated the contribution of ergonomics in achieving sustainability goals, for example, research by Saravia-Pinilla et al., (2016) and Meyer et al., (2017). Some research stated the contribution of sustainability in achieving ergonomic goals, for example, research by (Bolis et al., 2016) and Sobhani and Wahab (2017).

Literature Review

There are two points will be discussed in in literature review namely ergonomics and sustainability.

Ergonomics

According to IEA (2000), there are three scientific fields of ergonomics, namely:

1. Physical Ergonomics which is related to the abilities and limitations of human physical aspects including anatomy, anthropometry, physiology, and biomechanics. According to (Iridiastadi & Yassierli, 2014), physical ergonomics includes anthropometry, biomechanics, and work physiology. Research related to physical ergonomics includes product design (Thai et al., 2015), and musculoskeletal disorders due to work (Chan et al., 2022).
2. Cognitive Ergonomics is related to mental processes, such as perception, memory, reasoning, and motor response, that affect the interaction between humans, materials, and machines in a system. Topics are relevant to cognition such as mental workload, skilled performance, decision-making, human-computer interaction, training, human reliability, and work stress as these may relate to human-system design.
3. Organizational ergonomics is an aspect of ergonomics that uses a top-down socio-engineering systems approach in analysing, designing, and improving work systems and work organizations; where the results will be aligned with all constituent elements.

Ergonomics and Sustainability

Ergonomics is needed to address sustainability issues through the integration and implementation of sustainability principles (Haslam and Waterson, 2013). Ergonomics can be a tool to improve sustainability while reducing the negative effects of industry on ecosystems

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(Pavlovic-Veselinovic, 2014). Ergonomics is related to the interaction of people and their work environment and optimize those interactions to improve efficiency, safety, and comfort (Fischer et al., 2021). Ergonomics plays an important role in global supply chains by optimizing the interaction between workers and their work environment, promoting worker health and safety, and supporting social responsibility (Hasle and Jensen, 2012; Sampouw and Hartono, 2019). Human factors are instrumental in achieving SD and reducing global issues such as pollution, climate change, renewable energy, land change, and social issues (Thatcher and Yeow, 2016). Ergonomics plays a role in improving workforce sustainability through optimizing user-product interaction by considering the needs and desires of users, encouraging innovation, and supporting social responsibility (Meyer et al., 2017; Tosi, 2012). Several studies have been conducted on the contribution of ergonomics to environmental sustainability such as the concepts of agroecology (García-Acosta et al., 2014) and green ergonomics (Hanson, 2013; Thatcher, 2013) with a focus on optimizing production systems through green productivity and green efficiency. Some studies promote ergonomics interventions by considering the environment, economy, and society to design sustainable work systems (Zink, 2014). The concept of system sustainability extends the contribution of ergonomics to the socio-technical thinking approach (Thatcher and Yeow, 2016).

Methodology

This study's methodology started with a survey of the literature, looking for current, pertinent publications about sustainability and ergonomics. We used the Priority Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to perform a systematic literature review once the true problem had been determined. PRISMA is divided into three stages. The first step is identification, which involves finding pertinent material from a range of sources. The source might be found at Elsevier, Scopus, and Google Scholar. The number of detected articles from databases, websites, and other resources must be indicated in this phase. Screening is the second stage. This stage involves counting the number of objects that were screened, rejected, retrieved, and not recovered, as well as determining the cause of the rejection and non-retrieval. As part of the last stage, which is incorporated, the total of publications used in the literature review is reported Tahsin (2022). Elsevier was accessed through sciencedirect.com for the first stage of identification, while Google and Google Scholar were used for other approaches. There were 650 articles collected through the database dan 50 articles were collected through Google Scholar. The articles were filtered using the following keywords: sustainability, ergonomics, SDGs, indicators, and integrated framework. Then the second stage is screening, where articles that were not relevant to this study were eliminated. One hundred papers were eliminated because they were outdated (published more than five years ago) or because they were generally relevant but not appropriate for this study. The 550 articles were then grouped into more detail developed on the connection between ergonomics and sustainability in a framework, resulting in 50 suitable articles.

So, in the final stage, there were 50 articles used for this research. Articles related to the integration of ergonomics and sustainability consisted of 13 articles. These articles consist of ergonomics and sustainability integration framework (Sarbat & Ozmehmet Tasan, 2020), sustainable product manufacturing framework (Helleno et al., 2017; Lin et al., 2019; Mubin et al., 2023; Peralta Álvarez et al., 2017; Swarnakar et al., 2021; Tan et al., 2015; Vinodh et al., 2016; Zarte et al., 2019), corporate sustainability policy framework (Bolis et al., 2020), and social sustainability framework (Fatourehchi and Zarghami, 2020; Kumar et al., 2020; Lee et al., 2019).

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Based on the results of previous research, Sarbat & Ozmehmet Tasan (2020) then categorized the integration of ergonomics and sustainability into two parts. Where job/task, workplace and equipment, and work organization ergonomics are used as fundamental elements of ergonomics in the framework that is compiled, which can be seen in Figure 1.

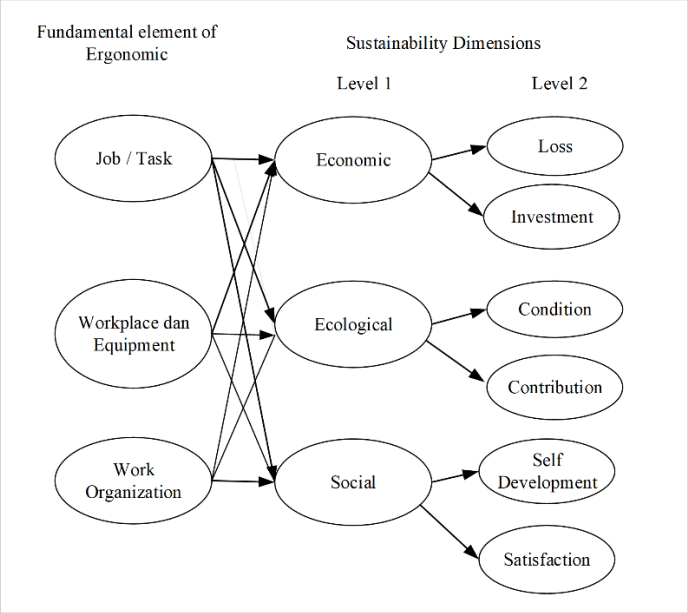


Figure 1: Basic Framework for The Integration of Ergonomics and Sustainability
Source: (Sarbat & Ozmehmet Tasan, 2020)

The main dimensions of sustainability at level 1 are the three pillars of sustainability (triple bottom line), namely economic, social, and environmental. While the subdimensions at level 2 are divided into two parts each, the definition for each can be seen in Table 1.

Table 1: Definition of Sustainability Subdimension Level 2

No	Definition
1.	*Loss* relates to the loss of money, time, and employee health in terms of medication, occupational diseases, injuries, and accidents caused by unfavorable working conditions.
2.	*Investment* relates to investments in training, personal development, and the workplace as to ergonomic invasions and environmental, health, and safety (EHS) issues.
3.	*The condition* relates to the physical conditions (noise, temperature, odor, dust, etc.) of the workstations in terms of time and complaints from workers and/or the public
4.	*Contribution* relates to contributing to ergonomically designed processes and environmental, health, and safety (EHS) issues in terms of charity, volunteering, and recycling
5.	*Self-development* relates to employee self-development in terms of environmental, health, and safety (EHS) training received, improvements made, and time spent.
6.	*Satisfaction* relates to employee satisfaction in terms of working conditions and/or the job they are responsible for.

Source: (Sarbat & Ozmehmet Tasan, 2020)

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Result

Swarnakar et al., (2021) developed a framework for assessing the sustainability of manufacturing processes based on reference values set by the organization, the indicators used still need to be improved. Tan et al., (2015) developed a sustainability assessment framework for small and medium manufacturing companies using 40 indicators, but these indicators still need to be implemented. Zarte et al., (2019) developed a sustainability assessment framework for production planning and control. Helleno et al., (2017) directed research connected with the coordination of maintainability and lean assembling markers to survey the assembling system. The outcomes show contrasts in the degree of supportability all through the assembling system, so it turns into an assessment of the assembling system. Mubin et al., (2023) proposed a new framework for assessing manufacturing sustainability that includes physical and mental workload. The results can identify various levels of sustainability and assist in decision-making. Peralta Álvarez et al., (2017) researched a framework to assess the sustainability of machining processes based on the triple-bottom-line approach. This framework helps identify the development and improvement of manufacturing technology. Vinodh et al., (2016) researched a framework for evaluating the sustainability performance of manufacturing processes in the product life cycle, by integrating life cycle assessment into value stream mapping. This framework can identify environmental impacts and assess potential improvements in terms of sustainability. Bolis et al., (2020) conducted research on a framework for integrating ergonomics (related to the needs and interests of workers) with sustainability through cooperation and collaboration within the organization. Fatourehchi and Zarghami, (2020), the social sustainability framework includes worker safety, worker comfort, and environmental issues. Research by Kumar et al., (2020) added indicators to the social sustainability framework, namely wages, benefits, health/safety, health insurance, and occupational health and safety certification. Lee et al., (2019) conducted research on critical factors for the success of social sustainability of social services, and the selected factors were accessibility and the possibility of participation. Sarbat & Ozmehmet Tasan (2020) proposed 17 ergonomics indicators (EIs) for the six subdimensions in their framework. To make the measurement of process performance in an organization more manageable, it is proposed that there are 8 additional EIs (Sarbat & Ozmehmet Tasan, 2022), see Table 2.

Table 2: Ergonomics Indicators

No.	Ergonomics Indicator	Reference
1.	Amount of mishap inactive days per year	Sarbat & Ozmehmet Tasan (2020)
2.	Amount of without damage days out of every year	
3.	The proportion of complete delays because of mishaps and wounds compared with the all-out work time each year	
4.	Expense on clinical medicines for mishaps, wounds, and word-related sicknesses	
5.	Total cases of employment diseases per year	
6.	Periodic investment cost for ergonomics interventions and EHS issues	
7.	Cost of EHS training of employees per year	
8.	Expense on workers' improvement each year	
9.	Expense on innovative work, innovation, and advancement each year to upgrade ergonomically and naturally - agreeable planned processes	
10.	Number of objections because of states of being (clamor, temperature, smell, dust, and so forth) each year	

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11.	Number of grievances from the local area each year	
12.	Number of days when there are ominous states of being (commotion, temperature, scent, dust, and so on) each year	
13.	Percentage of representatives working in negative circumstances prompting physical and psychological wellness issues each year	
14.	Number of exercises made for further developing working circumstances each year	
15.	A total of workers create altruistic commitments to EHS issues each year	
16.	The proportion of reused items/unrefined substances utilized in ergonomically planned processes each year	
17.	The proportion of yearly impetuses and advancements made for partners to give ergonomically and harmless to the ecosystem planned processes	
18.	The proportion of workers receiving EHS training per year	Sarbat & Ozmehmet Tasan (2022)
19.	The proportion of complete time spent because of EHS preparation compared with the all-out hours worked each year	
20.	Total of recommended upgrades carried out by workers each year	
21.	Periodic number of exercises made for the appropriate execution of the strategies connected with ergonomics intercessions and EHS issues	
22.	Periodic turnover rate of worker	
23.	The proportion of workers who are comfortable with their work	
24.	Total of grievances because of working circumstances not covered by respectable work each year	
25.	The extent of laborers taking part in administrative choices connected with ergonomics mediations and EHS issues each year	

Source: (Sarbat & Ozmehmet Tasan, 2020, 2022)

The fundamental element of ergonomics has changed to the field of ergonomics studies according to the IEA, which consists of physical, cognitive, and organizational ergonomics. This is done so that the resulting integration framework is more integrative and complete than previous frameworks, see Figure 2.

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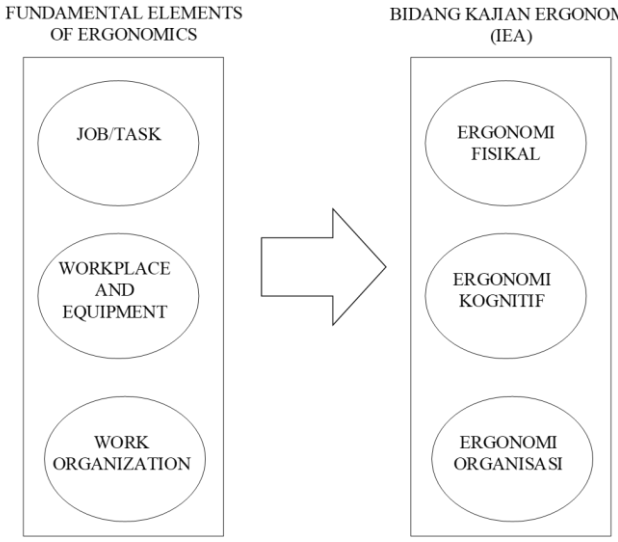


Figure 2: Change of Fundamental Elements of Ergonomics-to-Ergonomics Fields of Study

Source: (Sarbat & Ozmehmet Tasan, 2020)

Furthermore, a mapping between the fields of ergonomics (IEA), ergonomic indicators, and sustainability studies was carried out to see the relationship between each other, as can be seen in Figure 3.

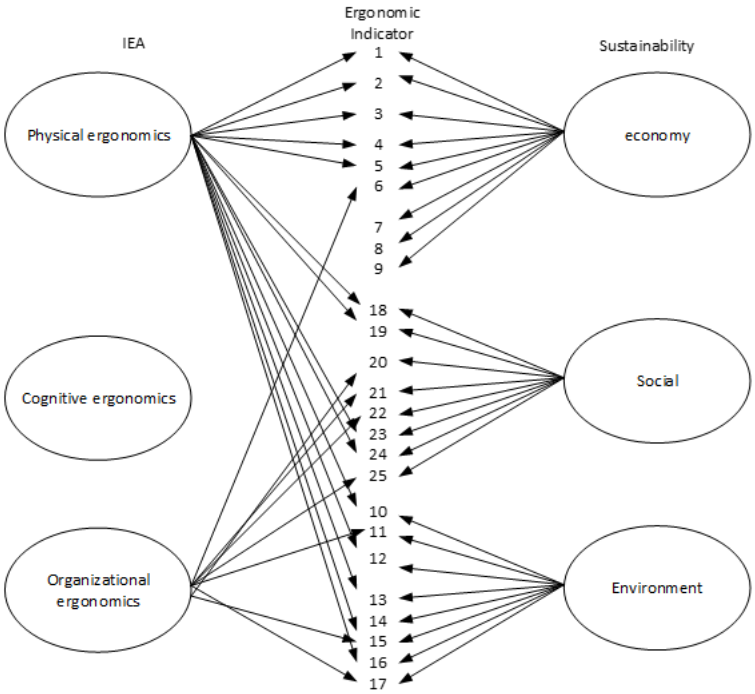


Figure 3: Mapping of Ergonomics (IEA), EI, and Sustainability Fields of Study

Source: (Sarbat & Ozmehmet Tasan, 2020, 2022)

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Conclusion

The PRISMA results show that a total of 650 articles were gathered, with fifty specifically sourced from Google Scholar. These articles underwent screening using sustainability, ergonomics, SDGs, indicators, and integrated framework. Out of the initial 650, 100 articles were eliminated due to being outdated (published over five years ago) or being relevant but not pertinent to the study. This left 550 articles, which were further categorized based on the relationship between ergonomics and sustainability within a framework, resulting in fifty suitable articles. There are 13 articles related to the integration of ergonomics and sustainability consisting of ergonomics and sustainability integration framework (Sarbat and Tasan, 2020), sustainable product manufacturing framework Helleno et al., 2017; Lin et al., 2019; Mubin et al., 2023; Peralta Álvarez et al., 2017; Swarnakar et al., 2021a; Tan et al., 2015; Vinodh et al., 2016; Zarte et al., 2019), corporate sustainability policy framework (Bolis et al., 2020) and social sustainability framework (Fatourehchi and Zarghami, 2020; Kumar et al., 2020; Lee et al., 2019). Based on the PRISMA literature review, it was noted that the Sarbat and Tasan framework (Sarbat & Ozmehmet Tasan, 2020) and other frameworks (Bolis et al., 2020; Fatourehchi and Zarghami, 2020; Helleno et al., 2017; Kumar et al., 2020; Lee et al., 2019; Lin et al., 2019; Mubin et al., 2023; Peralta Álvarez et al., 2017; Swarnakar et al., 2021; Tan et al., 2015; Vinodh et al., 2016; Zarte et al., 2019) already integrate ergonomics and sustainability. However, in the IEA approach, cognitive factors need to be more integrative. Therefore, future research should focus on the second level, considering not only cognitive factors but all levels that have not been covered.

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