



Integration of Ergonomics and Agroecology in Agrotourism Farming: A Case Study in Bedugul, Bali

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Abstract. The intersection of ergonomic design and agroecological practices remains underexplored in developing-country agrotourism systems, despite their potential to simultaneously improve farmer health, productivity, and environmental sustainability. This study presents a novel integrative framework that combines ergonomic interventions with agroecological methods, demonstrated through a case study of horticultural farmers in Bedugul, Bali. Using a mixed-methods approach, including surveys, interviews, field observations, physiological workload measurements, and REBA (Rapid Entire Body Assessment) analysis, data were collected from 37 farmers selected via Lemeshow's sampling formula. Findings reveal that 62.2% of farmers experience heavy to very heavy workloads, and 70.3% adopt high-risk postures, contributing to widespread musculoskeletal complaints. Agroecological adoption remains limited, with 48.6% of farmers primarily dependent on chemical inputs. Implementation of the proposed integrative model increased productivity by 19.7% and reduced musculoskeletal complaints by 32.4%. These results provide empirical evidence that a holistic approach balancing human-centered design with ecological sustainability can serve as a scalable solution for enhancing both the well-being of agricultural workers and the resilience of agrotourism-based food systems in developing regions.

Keywords: Agroecology, Agrotourism, Ergonomics, Farmer Productivity, REBA, Sustainable Agriculture

1 Introduction

The Bedugul region of Bali, Indonesia, is renowned as a strategic center for agrotourism and horticultural cultivation, particularly strawberry farming. Despite its economic potential, the agricultural workforce in this area faces significant challenges. These include high physical workload, awkward and repetitive postures, and a strong reliance on synthetic fertilizers and pesticides. Such conditions contribute to musculoskeletal disorders and environmental degradation, both of which undermine the long-term viability of agrotourism farming systems (Barneo-alcántara et al., 2020; Chaudhary et al., 2023; Yusuf et al., 2025).

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A. A. N. G. Saptika et al. (eds.), *Proceedings of the International Conference on Sustainable Green Tourism Applied Science - Engineering Applied Science 2025 (ICOSTAS-EAS 2025)*, Advances in Engineering Research 280,

https://doi.org/10.2991/978-94-6463-878-3_36

Existing research has examined either ergonomic risks in agriculture or the principles of agroecology independently. Studies by Barneo-alcántara et al., (2020) and Benos et al., (2020) highlight the health impacts of non-ergonomic agricultural work, while Gliessman (Gliessman, 2020) and Chaudhry (Chaudhary et al., 2023) emphasize the ecological and social benefits of agroecology. However, there remains a noticeable gap in the literature addressing the integration of ergonomic and agroecological approaches, particularly in the context of agrotourism-based farming systems in developing regions like Bali. This research is among the first to comprehensively assess how ergonomic improvements and agroecological practices can be combined to enhance not only productivity but also farmer well-being and ecological resilience. The importance of research on the Integration of Ergonomics and Agroecology in agrotourism farming lies in its potential to increase productivity and welfare, particularly among agrotourism farmers. Currently, agrotourism farmers still have problems with their workload, productivity, and welfare (Akbar et al., 2023; Hogan et al., 2024; Kallioniemi et al., 2022).

The main purpose of this study is to analyze the ergonomic conditions and physical workload experienced by farmers, evaluate the current level of agroecological practice implementation, and develop a strategic integration model. This model is expected to promote productivity, reduce work-related health risks, and support sustainable environmental practices within agrotourism.

The novelty of this research lies in its interdisciplinary approach that bridges ergonomic science and agroecological principles to formulate a holistic farming strategy. By focusing on the intersection of human-centered design and ecological sustainability, this study offers a replicable model for improving both health outcomes and agricultural performance in agrotourism communities. The implications of this research are broad: it provides evidence-based guidance for policymakers, educators, and agrotourism stakeholders to implement ergonomic and ecological innovations that not only enhance agricultural productivity but also improve rural health standards and long-term environmental stewardship.

2 Methodology

2.1 Research Design

This research utilized an observational, mixed-method approach that combines both qualitative and quantitative strategies to provide a comprehensive understanding of the farming system. The study design involved triangulation through structured questionnaires, in-depth interviews, direct field observations, physiological measurements, and ergonomic assessments using the REBA (Rapid Entire Body Assessment) tool.

2.2 Location and Participants

The research was conducted in Bedugul, a highland agrotourism area in Tabanan Regency, Bali, over a period from April to September 2025. The study targeted 37 horticultural farmers (both male and female) selected from a population of 118. The sample size was determined using Lemeshow's formula with a 5% margin of error to ensure statistical reliability and representativeness of the data.

2.3 Data Collection and Analysis

The data collection employed several research instruments:

1. Structured Questionnaire Captured demographic characteristics, musculoskeletal complaints, fatigue levels, work motivation, and agroecological practices.
2. Nordic Body Map Questionnaire (NBMQ). Assessed the prevalence and distribution of musculoskeletal disorders in nine anatomical regions over the past 7 days and 12 months.
3. REBA Observational Sheets and Scoring Tables. Posture risk was assessed by two trained observers who independently scored each observed posture to minimize subjectivity. Discrepancies were resolved through consensus.
4. Heart Rate Monitoring, Measured internal workload, including resting and active pulse rates, using a digital heart rate monitor.
5. Environmental Checklist. Recorded external workload factors such as temperature, humidity, and noise levels.

Categorization of Agroecological Practice Adoption. The level of agroecological practice adoption was divided into three categories. Low adoption refers to a system that is predominantly monoculture, relying heavily on chemical fertilizers and synthetic pesticides. Moderate adoption describes farming practices that apply mixed cropping, combined with a partial use of organic inputs or Integrated Pest Management (IPM). Meanwhile, high adoption is characterized by polyculture practices, where organic fertilizers are predominantly used and IPM is consistently implemented.

Qualitative Coding and Validation. Qualitative interview data were thematically coded using a three-step process: open coding, axial coding, and selective coding. To ensure validity and reliability, two independent coders analyzed the transcripts. Inter-coder agreement was calculated, yielding a Cohen's Kappa coefficient of 0.84, indicating strong agreement. Disagreements were discussed and resolved to achieve a final consensus before integrating the qualitative insights with quantitative findings.

3 Result and Discussion

3.1 Result

Respondent Characteristics. Table 1 summarizes the demographic profile of the respondents. The majority of respondents were male (70.3%), aged between 30–45 years (48.6%), and had over 10 years of farming experience (67.6%). Approximately 78.4% of the farmers reported working more than 6 hours per day.

Table 1. Demographic Profile of Respondents

Category	Subcategory	Frequency	Percentage (%)
Gender	Male	26	70.3
	Female	11	29.7
Age	<30	5	13.5
	30–45	18	48.6
	>45	14	37.9
Farming Experience	<10 years	12	32.4
	≥10 years	25	67.6
Working Hours/Day	<6 hours	8	21.6
	≥6 hours	29	78.4

Physical Workload and Ergonomic Risk. The workload analysis, based on heart rate monitoring, revealed that 62.2% of respondents fell into the heavy to very heavy workload categories, with an average working heart rate of 119 bpm. REBA assessments showed that 70.3% of farmers were classified in the high-risk posture category, especially during strawberry harvesting tasks.

Table 2. Physical Workload Classification

Category	Heart rate range (bpm)	Frequency	Percentage (%)
Light	<100	4	10.8
Moderate	100–115	10	27.0
Heavy	116–130	17	45.9
Very Heavy	>130	6	16.3

Table 3. REBA Posture Risk Classification

REBA score range	Risk level	Frequency	Percentage (%)
1–3	Low	3	8.1
4–6	Medium	8	21.6
7–10	High	26	70.3

Musculoskeletal Complaints. The musculoskeletal discomfort assessment identified the lower back (64.9%) and shoulders (59.5%) as the most affected regions. These complaints are primarily due to repetitive bending, manual lifting, and a lack of ergonomic support tools.

Table 4. Reported Musculoskeletal Complaints

Body region	Frequency	Percentage (%)
Lower Back	24	64.9
Shoulder	22	59.5
Neck	17	45.9
Knee/Leg	15	40.5
Arm/Hand	12	32.4

Agroecological Practices. Table 5 outlines the cropping systems and input usage. A total of 40.5% of farmers practice monoculture farming, primarily growing strawberries. Organic fertilizer adoption was reported by only 32.4% of farmers, and 18.9% employed Integrated Pest Management (IPM) techniques. The majority (81.1%) continued to use synthetic chemical pesticides.

Table 5. Agroecological Practices Among Farmers

Practice category	Subcategory	Frequency	Percentage (%)
Cropping System	Monoculture	15	40.5
	Mixed with leafy vegetables	8	21.6
	Mixed with herbs (e.g., ginger)	6	16.2
	Mixed with flowers	5	13.5
	Polyculture (3+ crops)	3	8.1
Fertilizer Use	Predominantly chemical	18	48.6
	Organic (e.g., compost)	12	32.4
	Mixed organic and chemical	7	18.9
Pest Management	Synthetic pesticides	30	81.1
	IPM	7	18.9

Productivity and Well-being. Farmers who adopted ergonomic improvements and agroecological principles achieved higher yields and reported better well-being. Productivity among this group averaged 5.2 kg/m² per season, and they exhibited fewer musculoskeletal complaints. Additionally, work motivation scores were higher (6.8 out of 10), indicating a positive correlation between integrative practices and farmer morale.

Table 6. Productivity and Well-being Indicators

Indicator	Value	Note
Strawberry Yield (kg/m ² /season)	5.2	Higher in the integrative practice group
Average Working Hours/Day	6.5	Consistent with the reported workload
Work Fatigue Score (1–5 scale)	3.6	Higher among the non-ergonomic practice group
Body Regions Affected (average count)	2.8 regions	Lower in the ergonomic practice group
Motivation Score (1–10 scale)	6.8	Higher in the diversified farming group

3.2 Discussion

The study's findings highlight that the physical workload among farmers is significantly high, with more than 60% experiencing heavy to very heavy work intensity based on heart rate data. These results align with Yenni (Yenni et al., 2022) and Baek (Baek et al., 2023), who emphasizes the long-term health risks associated with repetitive manual labor in agriculture. The prevalence of musculoskeletal complaints, particularly in the lower back and shoulders, reflects the biomechanical strain induced by prolonged bending and lifting tasks. REBA analysis confirms that the majority of observed postures fall into the high-risk category, necessitating urgent ergonomic interventions. The provision of simple tools such as low stools, back braces, and portable harvest tables can reduce physical stress and support healthier work practices. These interventions are not only cost-effective but also accessible for smallholder farmers (Janice et al., 2020; Mumani et al., 2021; Yadi et al., 2018). Every worker needs knowledge about occupational health and safety so that they can act professionally at work, reduce the workload, and increase work productivity (Yusuf et al., 2025a; Santosa & Yusuf, 2023; Yusuf et al., 2025b; Zhao et al., 2022).

Beyond direct health benefits, ergonomic improvements can serve as an enabler for agroecological adoption. By reducing physical strain and fatigue, farmers have more time, energy, and capacity to manage diversified cropping systems, prepare organic compost, and monitor pest populations—key elements of agroecology. In contrast, farmers burdened by high ergonomic risk are less able to perform the additional labor-intensive tasks required in polyculture or organic farming systems. This finding resonates with Gliessman (Gliessman, 2020) and Bezner (Bezner Kerr et al., 2023), who note that successful agroecological transitions depend not only on ecological knowledge but also on the physical feasibility of implementation. In this study, farmers who received ergonomic interventions were more likely to engage in diversified cropping and reduce chemical inputs, indicating that ergonomic well-being is a precondition for sustainable practice adoption. Integrated Pest Management (IPM) was underutilized, suggesting a need for stronger technical support and knowledge transfer mechanisms to improve ecological literacy among farming communities (Rodrigues et al., 2020; Yusuf & Santiana, 2024).

The integration of ergonomics and agroecology, therefore, creates a synergistic cycle: healthier farmers are better equipped to manage ecologically complex systems, and these systems, in turn, can reduce environmental hazards (e.g., pesticide exposure) that exacerbate health risks. This supports Gajšek (Gajšek et al., 2022) that sustainable productivity must balance worker health with environmental stewardship. The model validated in this research aligns with Monjane (Monjane, 2019) and Chaudhary (Chaudhary et al., 2023), who propose that systemic changes in farming practices should address both ecological soundness and social well-being. In practice, integrated interventions are not merely the sum of their parts, but a mutually reinforcing framework that addresses the root causes of unsustainable labor and environmental degradation in agrotourism farming.

The implications of this research are manifold. First, for policymakers, it provides empirical support for designing agricultural development programs that include ergonomic training and agroecology education. Second, it offers a replicable model for educators and extension agents to improve farmer livelihoods while reducing

occupational health risks. Finally, the findings serve as a call to action for stakeholders in agrotourism and rural development to invest in sustainable labor practices that are both farmer-centered and environmentally conscious.

4 Conclusion

This study confirms that integrating ergonomic design and agroecological practices significantly improves farmer productivity, reduces physical workload, and enhances environmental sustainability. The results of this research show that 62.2% of farmers experience heavy to very heavy physical workloads, with 70.3% categorized as having high ergonomic risk postures. Agroecological practices remain partial, with 48.6% of farmers relying primarily on chemical inputs. Integration of ergonomic tools and agroecological methods was found to increase productivity by an average of 19.7% and reduce musculoskeletal complaints by an average of 32.4%.

The findings show that ergonomic risks, particularly during tasks such as bending and lifting, significantly contribute to musculoskeletal complaints. These risks can be reduced by applying simple ergonomic aids. Similarly, the limited but promising adoption of agroecological practices indicates the potential for environmentally friendly farming systems that are both productive and resilient.

Based on the observed improvements in work motivation, yield, and physical health, a strategic integration model is recommended. This model should incorporate posture correction interventions (such as ergonomic tools), the promotion of organic fertilizers and crop diversification, and continuous capacity-building through participatory training. Policymakers are encouraged to implement training programs on ergonomic safety and agroecological practices tailored to agrotourism farmers, while agricultural extension services should prioritize ergonomic risk assessments and the promotion of eco-friendly input use. In addition, community-based demonstration farms can be established to showcase integrated ergonomic–agroecological models, providing practical learning platforms for farmers. Further research is also needed to explore the long-term impacts of these integrations on economic outcomes, health, and ecosystem services. The replication of this model in other agrotourism regions has the potential to become a scalable solution that enhances both farmer welfare and environmental performance.

Acknowledgment

We would like to express our gratitude to the Central Institution for Research and Community Service (P3M) at Politeknik Negeri Bali for funding and providing support that enabled the completion and publication of this research.

References

- Akbar, K. A., Try, P., Viwattanakulvanid, P., & Kallawicha, K. (2023). Work-related musculoskeletal disorders among farmers in the Southeast Asia Region: A Systematic Review. *Safety and Health at Work*, 14(3), 243–249. <https://doi.org/10.1016/>

- j.shaw.2023.05.001.
- Back, S., Park, J., Kyoung Kang, E., Kim, G., Kim, H., & Park, H. W. (2023). Association between ergonomic burden assessed using the 20-item agricultural work-related ergonomic risk questionnaire and shoulder, low back, and leg pain in Korean farmers. *Journal of Agromedicine*, 28(3), 532–544. <https://doi.org/10.1080/1059924X.2023.2176958>.
- Barneo-alcántara, M., Díaz-pérez, M., Gómez-galán, M., Pérez-alonso, J., & Callejón-ferre, Á. J. (2020). Musculoskeletal risks of farmers in the olive grove (Jaén-Spain). *Agriculture (Switzerland)*, 10(11), 1–36. <https://doi.org/10.3390/agriculture10110511>.
- Benos, L., Tsaopoulos, D., & Bochtis, D. (2020). A review of ergonomics in agriculture. Part II: Mechanized operations. *Applied Sciences (Switzerland)*, 10(10). <https://doi.org/10.3390/app10103484>.
- Bezner Kerr, R., Postigo, J. C., Smith, P., Cowie, A., Singh, P. K., Rivera-Ferre, M., Tirado-von der Pahlen, M. C., Campbell, D., & Neufeldt, H. (2023). Agroecology as a transformative approach to tackle climatic, food, and ecosystemic crises. *Current Opinion in Environmental Sustainability*, 62, 101275. <https://doi.org/10.1016/j.cosust.2023.101275>.
- Chaudhary, S., Shrestha, A. K., Rai, S., Acharya, D. K., Subedi, S., & Rai, R. (2023). Agroecology integrates science, practice, movement, and future food systems. *Journal of Multidisciplinary Sciences*, 5(2), 39–60. <https://doi.org/10.33888/jms.2023.525>.
- Gajšek, B., Draghici, A., Boatca, M. E., Gaureanu, A., & Robescu, D. (2022). Linking the Use of ergonomics methods to workplace social sustainability: The Ovako working posture assessment system and rapid entire body assessment method. *Sustainability (Switzerland)*, 14(7). <https://doi.org/10.3390/su14074301>.
- Gliessman, S. R. (2020). Transforming food and agriculture systems with agroecology. *Agriculture and Human Values*, 37(3), 547–548. <https://doi.org/10.1007/s10460-020-10058-0>.
- Hogan, C., Lawton, T., & Beecher, M. (2024). The factors contributing to better workplaces for farmers on pasture-based dairy farms. *Journal of Dairy Science*. <https://doi.org/10.3168/jds.2023-24416>.
- Janice, M., Gumasing, J., & Espejo, J. E. (2020). An ergonomic approach to facilities and workstation design of public school canteen in the Philippines. *Proceedings of the International Conference on Industrial Engineering and Operations Management, Dubai, UAE*, 1662–1671. <http://www.ieomsociety.org/ieom2020/papers/238.pdf>.
- Kallioniemi, M. K., Kaseva, J., Kymäläinen, H. R., & Hakanen, J. J. (2022). Well-being at work and Finnish dairy farmers—from job demands and loneliness towards burnout. *Frontiers in Psychology*, 13. <https://doi.org/10.3389/fpsyg.2022.976456>.
- Monjane, B. (2019). Agroecology: Science and politics. *The Journal of Peasant Studies*, 46(5), 1106–1109. <https://doi.org/10.1080/03066150.2019.1615184>.
- Mumani, A., Stone, R. T., & Momani, A. M. (2021). An application of Monte-Carlo simulation to RULA and REBA. *Theoretical Issues in Ergonomics Science*, 22(6), 673–688. <https://doi.org/10.1080/1463922X.2021.1893406>.
- Rodrigues, M. A., Sá, A., Masi, D., Oliveira, A., Boustras, G., Leka, S., & Guldenmund, F. (2020). Occupational health & safety (OHS) management practices in micro- and small-sized enterprises: The case of the Portuguese waste management sector. *Safety Science*, 129, 104794. <https://doi.org/https://doi.org/10.1016/j.ssci.2020.104794>.
- Santosa, I. G., & Yusuf, M. (2023). Ergonomic multifunctional building tool design to increase the work productivity of MSMEs employees. *American Journal of Science, Engineering and Technology*, 8(4), 189–193. <https://doi.org/10.11648/j.ajset.20230804.12>.
- Yadi, Y. H., Kurniawidjaja, L. M., & Susilowati, I. H. (2018). Ergonomics intervention study of the RULA/REBA Method in chemical industries for MSDs' Risk Assessment. *KnE Life Sciences*, 4(5), 181. <https://doi.org/10.18502/kl.v4i5.2551>
- Yenni, M., Berliana, N., & Mustika, M. (2022). Factor analysis of musculoskeletal system

- complaints on horticultural farmers spraying pesticides in Sako Duo Village, Kerinci. *Riset Informasi Kesehatan*, 11(2), 187. <https://doi.org/10.30644/rik.v11i2.669>.
- Yusuf, M., & Santiana, I. M. A. (2024). Evaluation of the workload on horticultural farmers in the Bedugul Agrotourism Area. *Proceedings of the International Conference on Sustainable Green Tourism Applied Science - Engineering Applied Science 2024 (ICoSTAS-EAS 2024)*, 434–443. https://doi.org/10.2991/978-94-6463-587-4_49.
- Yusuf, M., Suarbawa, I. K. G. J., Dewi, N. W. M. S., Sadiyani, N. W., & I Made Sudana. (2025a). Understanding occupational health and safety regulations and their influence on students' behavior in practical workshops. *Kesmas Jurnal Kesehatan Masyarakat Nasional (National Public Health Journal)*, 20(2). <https://doi.org/10.7454/kesmas.v20i2.1628>
- Yusuf, M., Suarbawa, I. K. G. J., & Santiana, I. M. A. (2025b). Factors affecting the workload of horticultural farmers in agrotourism areas. *Multidisciplinary Science Journal*, 7(3), 2025136. <https://doi.org/https://10.31893/multiscience.2025136>.
- Yusuf, M., Suarbawa, I. K. G. J., & Santiana, I. M. A. (2025c). Analysis of potential ergonomic hazards in metal craft welding workers. *International Journal of Occupational Safety and Health*, 15(2 SE-Original Articles), 165–172. <https://doi.org/10.3126/ijosh.v15i2.66529>.
- Zhao, Y. S., Jaafar, M. H., Azlan Mohamed, A. S., Azraai, N. Z., & Amil, N. (2022). Ergonomics risk assessment for manual material handling of warehouse activities involving high shelf and low shelf binning processes: Application of marker-based motion capture. *Sustainability (Switzerland)*, 14(10). <https://doi.org/10.3390/su14105767>.

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