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ABSTRACT

This study analyzes the impacts of climate change and heat stress exposure on the occupational safety and health of Ecuadorian agricultural workers through a comprehensive approach integrating regulatory, technical, and preventive dimensions. The research was conducted within a critical socio-legal epistemological framework, employing a qualitative, exploratory-descriptive design based on a systematic literature review. Documentary analysis was applied to scientific sources, national and international regulations, constitutional jurisprudence, and specialized literature addressing occupational risks and climate adaptation.

The findings indicate that working conditions in the agricultural sector are being significantly altered by climate change, leading to an intensification of thermal, biological, and psychosocial risks. The study identifies an urgent need to adapt working hours through rotating shifts and climate-smart scheduling, alongside complementary measures such as training workers to recognize heat stress symptoms, providing personal protective equipment, implementing environmental monitoring systems, and improving rural infrastructure.

The research also highlights the importance of engaging social stakeholders while acknowledging inequalities affecting vulnerable groups, including women, older adults, Indigenous peoples, and informal workers. The study concludes that ensuring occupational safety and health for Ecuadorian agricultural workers in the context of climate change requires an intersectional and adaptive approach grounded in current legal frameworks and coordinated action among the State, employers, workers, and the Ecuadorian Social Security Institute. Only through a holistic strategy can labor resilience and sustainability in rural areas be strengthened.

KEYWORDS: Climate change, occupational safety and health, working time adaptation, heat stress, agricultural labor.

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INTRODUCTION

Climate change represents a significant threat to the occupational health and safety of agricultural workers worldwide. In Ecuador, this phenomenon is reflected in a sustained increase in temperatures, greater exposure to solar radiation, and increasing climate variability, all of which have intensified rural workers' exposure to thermal stress (FAO, 2021; IPCC, 2023). This situation poses major challenges for the organization of agricultural work and the protection of farmworkers' health, as they carry out their activities under increasingly adverse environmental conditions (ILO, 2022).

In this context, it is important to consider the arguments presented by authors such as Gómez et al. (2023), who point out that climatic changes not only affect agricultural productivity but also increase occupational health risks for workers, particularly in sectors where labor is performed outdoors without adequate prevention and protection measures.

Despite the relevance of this issue, there is a limited number of studies addressing it from a local perspective, which constitutes a significant obstacle to the design of public policies adapted to the specific climatic, socioeconomic, and labor realities of Ecuadorian agricultural workers.

The legal foundation of this issue is established in the Constitution of the Republic of Ecuador (CRE), which recognizes the right to health as a fundamental guarantee in Article 32, while Article 14 affirms the population's right to live in a healthy and ecologically balanced environment. Likewise, Article 66, paragraph 2, guarantees the right to a dignified life, which includes the right to safe working conditions. These constitutional provisions are aligned with Sustainable Development Goals 3 (Good Health and Well-Being), 8 (Decent Work and Economic Growth), and 13 (Climate Action), which promote safe working environments, occupational health protection, and resilience to climate-related risks.

Within this legal framework, adapting working hours in the agricultural sector becomes a necessary response to increasing thermal stress, promoting preventive and adaptive strategies that reduce the negative impact of climate change on workers' health. Previous studies conducted by the International Labour Organization have examined the relationship between climate change and agricultural labor; however, a gap remains in the scientific literature regarding the Ecuadorian context, particularly with respect to the adaptation of working hours as a preventive measure against thermal stress.

This bibliographic research seeks to address this gap by analyzing the impacts of climate change and thermal stress on the occupational safety and health of Ecuadorian agricultural workers, differentiating itself from previous studies by focusing on the national context and on the potential implementation of work-shift rotation and other adaptive mechanisms aimed at reducing occupational risks.

The general objective of this study is to analyze the impacts of climate change and exposure to thermal stress on the occupational safety and health of Ecuadorian agricultural workers, using a comprehensive approach that integrates regulatory, technical, and preventive dimensions. The specific objectives are to: (i) identify preventive, adaptive, and workplace adjustment measures to mitigate the effects of

climate change and thermal stress on workers' occupational health; and (ii) identify specific occupational health risks derived from exposure to thermal stress.

The analysis is grounded in occupational risk management theory (Reason, 2000) and climate change adaptation theory (Smit & Wandel, 2006), with the aim of articulating occupational health literature with climate and agricultural studies relevant to the Ecuadorian context.

Development

It is necessary to begin by clarifying that, pursuant to Article 10 of the Ecuadorian Labor Code (C.T.), an employer is defined as any natural or legal person who utilizes the services of one or more individuals under a contractual relationship. This legal definition is consistent with the criterion proposed by Villavicencio Roca (2019), who emphasizes that the employer assumes responsibility for the payment of remuneration and for fulfilling the obligations derived from the employment contract, within the framework of subordination under which the worker provides lawful and personal services. Similarly, De la Cueva (2016) conceptualizes the employer as the individual who organizes, administers, and directs the work of others within a productive structure, acting as the holder of the workplace and assuming responsibility for the risks inherent in the employment relationship.

Conversely, Article 9 of the Labor Code defines a worker as a person who undertakes to provide services or perform tasks in exchange for remuneration. Pérez Botija (2019) further explains that a worker is a natural person who, by virtue of a contract, personally carries out professional activities on behalf of another and under conditions of dependence or subordination, receiving compensation in return. Carbonell Paredes (2020) reinforces this interpretation, arguing that a worker contributes labor power within a legal relationship characterized by dependence, continuity, and remuneration, thereby constituting a fundamental pillar of organizational labor dynamics.

Once these legal and doctrinal definitions are clarified, it becomes essential to examine how this employment relationship is transformed within contexts of emerging risk, particularly climate change. In the Ecuadorian agricultural sector—where activities are predominantly performed outdoors and under highly variable climatic conditions—the employer's obligation to guarantee a safe working environment acquires renewed complexity. Workers' exposure to thermal stress not only challenges individual health but also imposes additional demands in terms of occupational safety and risk prevention, in accordance with Article 410 of the Labor Code.

Climate change is a global phenomenon that directly affects agricultural activity, especially in vulnerable regions such as Latin America and, more specifically, Ecuador. Rising average temperatures, intensified climate variability, and the increasing frequency of extreme events—such as heat waves—have significantly heightened occupational health and safety risks for rural workers (IPCC, 2022). Consequently, climate change has become an urgent global concern, affecting not only crop productivity and sustainability but also the working conditions of agricultural laborers (Quintana & Aguilar, 2020).

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Within the Ecuadorian context, this issue is particularly significant, as agriculture remains one of the principal pillars of the national economy and rural employment. Nevertheless, climate change is producing substantial alterations in agricultural working conditions, directly impacting workers' health, productivity, and the organization of labor. Guamán and Stoessel (2022) argue that these emerging challenges require a restructuring of occupational safety and health policies in rural areas, integrating adaptive measures capable of responding to rising temperatures, increased solar exposure, and the growing frequency of extreme climatic events.

In this respect, Article 326, paragraph 5 of the Constitution of the Republic of Ecuador (CRE) guarantees every person the right to perform work activities in an adequate and suitable environment that safeguards health, integrity, safety, hygiene, and well-being. This constitutional mandate implies that climate variability should not undermine occupational health. Such risks may be mitigated through the adaptation of working hours or the implementation of complementary measures aligned with both workers' protection needs and organizational requirements, ensuring that neither party is disproportionately affected.

This research addresses the existing gap by examining in depth the intersection between climate change, occupational risks, and the potential need to adjust working hours within agricultural settings. Understanding this relationship is crucial for designing adaptation strategies that protect agricultural workers while simultaneously preserving sectoral sustainability and competitiveness. Accordingly, employers must comply with the provisions established in Article 42, paragraph 29 of the Labor Code, which mandates the provision of appropriate work clothing that meets protective and preventive standards, aimed at minimizing occupational risks arising from prolonged exposure to climate change and thermal stress.

The study of occupational safety and health among Ecuadorian agricultural workers in the context of climate change and thermal stress is relevant at both theoretical and practical levels. From a theoretical standpoint, as noted by Cedeño et al. (2024), this research contributes to expanding knowledge regarding the mechanisms through which climatic alterations translate into new challenges affecting rural workers' health and well-being. It also strengthens the conceptual articulation between occupational risk management and climate change adaptation frameworks.

From a practical perspective, the findings carry direct implications for the design and implementation of public policies aimed at safeguarding agricultural workers, as well as for the development of more resilient organizational strategies within sector-related enterprises (Orellana et al., 2020). Identifying the primary occupational risks associated with climate change and thermal stress enables an assessment of the feasibility of adapting working hours, considering the magnitude and severity of the effects generated by exposure to climate-related hazards during agricultural activities. The International Labour Organization (ILO, 2024) has emphasized that prolonged exposure to excessive heat, solar ultraviolet radiation, extreme weather events, workplace air pollution, vector-borne diseases, and agrochemicals significantly reduces workers' capacity to perform their duties, directly compromising health and safety.

Within this framework, it is essential to recognize that occupational health—according to the International Labour Organization (ILO, 2023)—involves the promotion and maintenance of the highest attainable level of physical, mental, and social well-being for workers across all occupations. This definition aligns with Article 326, paragraph 5 of the CRE, as well as with the employer's obligation to protect workers' physical integrity under Articles 42, paragraphs 1, 3, 6, 7, 11, and 29 of the Labor Code.

As a signatory to the Protocol of San Salvador, Ecuador acknowledges its obligation to guarantee occupational safety and hygiene and to prevent occupational diseases. In this context, global climatic transformations have significantly impacted the Ecuadorian agricultural sector. Rising temperatures, increasingly erratic precipitation patterns, and the growing incidence of extreme weather events have profoundly altered environmental and productive conditions in rural areas (Cuenca et al., 2024). These factors have affected crop viability and sustainability, while simultaneously generating adverse health effects for workers exposed to such conditions over prolonged periods. To mitigate these risks, preventive and protective measures must be implemented during the working day, including the rotation of shifts among workers.

Climate change has produced multiple meteorological and environmental transformations that directly affect Ecuadorian agricultural workers. Rising temperatures, increased droughts and floods, and the proliferation of pests and diseases have introduced new occupational risks (Jadán et al., 2024). These climatic pressures have intensified daily hazards, making it imperative to understand their scope and severity in order to design effective prevention and mitigation strategies that protect this vulnerable population (Guamán & Stoessel, 2022).

This perspective is reinforced by Article 4 of the Andean Instrument on Occupational Safety and Health (2004), which mandates the promotion of improved occupational safety and health conditions to prevent harm to workers' physical and mental integrity, including the provision of adequate protective equipment. Articles 9 and 11 further emphasize the State's role in developing information systems and management mechanisms aimed at reducing occupational risks. Consequently, employers are obligated to adopt measures in all workplaces that substantially minimize risks arising from labor activities.

Finally, Rito and Pacají (2022) argue that understanding the multidimensional impacts of climate change on agriculture is essential for designing integrated adaptation and mitigation strategies. Such strategies must address not only productive challenges but also the social, economic, and labor dimensions of this environmental phenomenon. Only through a holistic and coordinated approach can the long-term resilience and sustainability of this foundational sector of Ecuador's economy and rural development be ensured.

Occupational Risks Associated with Climate Change in Agriculture

Climate change has introduced new and progressively intensifying risks to the safety and well-being of workers in Ecuador's agricultural sector. Among the most significant challenges is prolonged exposure to elevated temperatures and solar radiation, conditions that can result in thermal stress, dehydration, sunburn, heat exhaustion, and heatstroke.

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Beyond their direct physiological impact, these climatic stressors increase the probability of occupational accidents due to fatigue, diminished concentration, and reduced reaction capacity (Jiménez et al., 2024). In this context, Article 3, paragraph 5 of the Occupational Safety and Health Regulation (2024) becomes particularly relevant, as it establishes that risks to workers' safety and health may arise depending on the intensity and duration of exposure within the workplace.

Heat-related hazards are not the only concern. The growing frequency and intensity of extreme weather events—such as torrential rainfall, floods, and severe storms—have substantially increased agricultural workers' exposure to field-related accidents (Logroño & Muñoz, 2020). Such events generate hazardous working conditions, including slippery surfaces, falling debris, unstable terrain, and electrical hazards. Additionally, climate-driven changes have facilitated the proliferation of pests and infectious diseases, introducing new biological risks that further compromise workers' health.

Article 41 of the Occupational Safety and Health Regulation (2024) specifies that physical risks derive from exposure to physical agents capable of producing harmful effects on workers' safety and health. These agents include extreme temperatures—both heat and cold—as well as environmental humidity, factors inherent to agricultural labor. The inclusion of these environmental variables within the regulatory framework underscores the necessity of adopting targeted measures to safeguard occupational health and minimize long-term adverse consequences.

Given this scenario, it is imperative that labor authorities, employers, and workers in Ecuador's agricultural sector ensure strict compliance with the Occupational Safety and Health Regulation (2024), particularly regarding employers' obligations to guarantee comprehensive health management. Article 16 further recognizes workers' right to perform their duties in an adequate and suitable environment that allows for the full exercise of their physical and mental capacities. This right acquires heightened relevance in contexts characterized by environmental instability and increased exposure to climate-related risks.

The existing regulatory framework implies, on the one hand, the development of safety protocols tailored to the climatic particularities of each geographical region; and on the other, the provision of appropriate personal protective equipment, accompanied by strengthened training in occupational health and safety. Only through a proactive and integrated approach can the integrity and well-being of the Ecuadorian agricultural workforce be effectively protected (Chávez, 2021). Likewise, the adoption of occupational safety policies grounded in preventive principles—such as systematic hazard identification, risk assessment and control, and the cultivation of a prevention-oriented culture encompassing promotion, surveillance, and health care—is essential for ensuring workers' safety (Occupational Safety and Health Regulation, 2024, Art. 5).

Climate change not only affects agricultural productivity and sustainability; it also poses a direct threat to the health of rural workers. Prolonged exposure to extreme environmental conditions—particularly high temperatures and intense solar radiation—has been associated with a spectrum of occupational health problems, ranging from thermal stress and dehydration to cardiovascular and neurological disorders (Amat et al., 2020). These risks are compounded by the physically demanding nature of agricultural

labor and by precarious employment conditions that persist in many rural areas. For this reason, strict compliance with Article 56 of the Occupational Safety and Health Regulation (2024) is essential, as it mandates the provision of adequate work clothing and personal protective equipment in accordance with technical specifications governing their use, maintenance, and replacement, thereby ensuring effective prevention and control of occupational hazards.

Beyond physical health impacts, climate change also exerts significant psychological effects on agricultural workers. Climatic uncertainty, fluctuating productivity, and the persistent threat of income and livelihood loss contribute to elevated levels of stress, anxiety, and depression (González et al., 2020). These psychosocial pressures are exacerbated by limited access to healthcare services and psychosocial support in rural areas, further increasing workers' vulnerability.

Addressing the safety and well-being of agricultural workers therefore requires a comprehensive strategy that strengthens both occupational risk prevention mechanisms and the broader resilience of the sector. This involves not only implementing mitigation protocols but also reinforcing social security systems and improving working conditions, including access to healthcare and psychological support adapted to rural realities (Toledo et al., 2023; Moreira & Merchán, 2023). In this regard, Article 6, paragraph 16 of the Organic Health Law establishes that safety standards and environmental conditions in workplaces must be oriented toward preventing and controlling occupational diseases, thereby minimizing exposure to risks—particularly those associated with climate change and thermal stress in agricultural contexts.

Adaptive Strategies in the Agricultural Sector

A central strategy in responding to climate change within the agricultural sector is the rotation of working schedules, particularly during periods of peak solar radiation. Reorganizing working hours reduces workers' cumulative thermal load and contributes to preventing heatstroke, dehydration, and extreme fatigue. The International Labour Organization (ILO, 2022) explicitly recommends such measures in outdoor agricultural activities characterized by sustained physical exertion.

The normative foundation for this strategy is firmly anchored in the Constitution of the Republic of Ecuador (2008). Article 33 guarantees the right to work under dignified conditions, while Article 66, paragraph 3, enshrines the right to personal integrity. Moreover, Article 326, paragraph 5 imposes upon the State the obligation to ensure safe and healthy working environments. Together, these constitutional provisions establish a binding framework that supports adaptive adjustments to labor organization in the face of climate-related risks.

At the statutory level, the Labor Code requires employers to ensure workplace safety and hygiene and permits the reorganization of working hours when special circumstances arise that affect workers' health. In parallel, the Occupational Safety and Health Regulation mandates the identification, assessment, and control of risks derived from excessive heat exposure. Thus, both constitutional and regulatory instruments provide sufficient legal basis for adopting adaptive scheduling mechanisms in agricultural settings.

From a jurisprudential standpoint, the Constitutional Court of Ecuador, through Judgment No. 1292-19-EP/21, recognized the necessity of applying differentiated measures to protect workers in vulnerable situations effectively. This reasoning is particularly relevant for agricultural workers exposed to thermal stress as a result of structural and environmental conditions. Similarly, Judgment No. 0507-13-EP/21 reaffirmed the State's obligation to prevent occupational risks through concrete and effective actions aimed at safeguarding workers' health and physical integrity.

Doctrinal contributions further reinforce the legitimacy of adapting working hours as a climate response strategy. Rodríguez-Morales and Bonilla-Aldana (2020) argue that prolonged heat exposure in tropical agricultural zones necessitates a reconfiguration of working time, incorporating active rest periods and shifts scheduled during cooler hours. González-Arias et al. (2020) maintain that personnel rotation, when combined with continuous hydration protocols and appropriate protective clothing, significantly mitigates the impact of thermal stress on occupational health. Likewise, Mora-Rivera and García-Mora (2021) advocate for the establishment of national protocols that institutionalize these practices within occupational risk prevention programs for the agricultural sector.

However, schedule rotation alone is insufficient. Effective adaptation requires a broader framework that integrates complementary measures, including training programs focused on early detection of thermal stress symptoms, provision of suitable personal protective equipment, implementation of early meteorological warning systems, improvement of shaded rest infrastructure, and strengthened State oversight to ensure compliance with occupational health regulations.

Climate change has markedly intensified occupational risks in agriculture, particularly in Ecuador's coastal regions, where elevated temperatures and humidity compound thermal stress. Yet, exposure to risk is not homogeneous. It intersects with structural and social variables—such as gender, age, ethnicity, contractual status, and geographic location—that produce differentiated levels of vulnerability. An intersectional lens is therefore indispensable for understanding how pre-existing inequalities shape agricultural workers' occupational health outcomes and for designing proportionate and equitable policy responses.

From a gender perspective, rural women frequently experience a dual workload, combining agricultural labor with domestic responsibilities. This dynamic extends their exposure to extreme heat conditions and often limits access to adequate personal protective equipment (UN Women, 2022). Precarious employment arrangements further impede the recognition and protection of women's labor rights, particularly in informal or family-based agricultural settings. Tasks such as washing tools contaminated with agrochemicals—often performed within domestic spaces—entail prolonged and largely invisible exposure to harmful agents, posing cumulative risks to women agricultural workers' health.

Age constitutes another critical variable. Older workers exhibit reduced physiological adaptability to extreme heat, increasing susceptibility to heat exhaustion, dehydration, and related pathologies (FAO, 2023). As tolerance to physical exertion declines with age, adaptive scheduling strategies must account for biological limits and incorporate

differentiated measures that recognize workers' varying capacities to cope with thermal stress.

Ethnicity further deepens vulnerability. In Ecuador, a substantial proportion of agricultural workers belong to Indigenous and Afro-descendant communities, groups that have historically faced structural barriers to accessing healthcare services, complaint mechanisms, and social security coverage (CDKN, 2023). These communities are frequently located in remote rural areas where labor inspection is limited and informality predominates, intensifying exposure to climate-related risks. Under such conditions, State intervention cannot be fragmented or generic. Effective coordination among institutions—such as the Ministry of Labor, the Ministry of Public Health, and the Ecuadorian Social Security Institute (IESS)—is essential to implement inclusive, intersectoral policies that address structural inequalities, promote equitable access to services, and ensure effective oversight in high-risk sectors.

FAO (2023) underscores the importance of inclusive agricultural policies that acknowledge structural differences among rural actors, while UN Women (2022) emphasizes that integrating a gender perspective into climate policy is indispensable for achieving equitable protection. Consequently, occupational health in Ecuador's agricultural sector must be conceptualized as a complex public issue shaped by environmental, social, and institutional variables requiring sustained and technically grounded State engagement.

Within this framework, the proposal of an "adaptive working day" has gained prominence. This concept refers to reorganizing working time according to climatic conditions and workers' physiological capacities. Moreno Martín and Inglés Torruella (2024) consider the measure conceptually robust; however, they caution that its implementation in Ecuador faces significant institutional, technical, and financial constraints—particularly within micro and small rural production units where informality and limited State presence restrict operational feasibility.

Addressing the occupational health impacts of climate change therefore demands a critical intersectional approach supported by coordinated State action. Public policies must move beyond homogeneous frameworks that overlook structural disparities. Instead, they must be tailored to the differentiated realities of vulnerable groups, thereby ensuring the effective realization of the right to dignified work in safe and healthy environments.

Technological innovation also offers significant opportunities to enhance climate resilience within the agricultural workforce. Wearable monitoring devices, environmental sensors, and real-time alert systems can facilitate early detection of heat-related conditions (Pérez et al., 2023). Similarly, automation and robotics may reduce manual labor exposure under hazardous conditions, while digital platforms could introduce greater flexibility in workforce organization, thereby minimizing direct climate exposure.

Ultimately, a comprehensive and multidimensional workforce management strategy is required. By integrating adaptive scheduling, intersectional public policies, technological innovation, and institutional coordination, Ecuador's agricultural sector can strengthen its capacity to protect workers, sustain productivity, and ensure long-term resilience in

the face of climate change. The articulation of these strategies within a coherent action plan, supported by public authorities, employers, and workers themselves, is essential to safeguarding the livelihoods and well-being of those who sustain the country's agricultural economy.

Rotation of Working Hours in the Ecuadorian Agricultural Sector

In light of the increasing challenges posed by climate change in Ecuador's agricultural sector, it becomes necessary to identify adaptive mechanisms capable of mitigating risks to workers' health and safety. Among the strategies discussed in comparative contexts is the rotation or reorganization of working hours in agricultural activities.

The introduction of more flexible and, where appropriate, shorter working schedules may contribute substantially to reducing exposure to extreme climatic conditions (Huilca & Baño, 2021). Limiting time spent under high temperatures, intense solar radiation, and other environmental hazards decreases the likelihood of heatstroke, dehydration, cardiovascular strain, and related occupational pathologies. Furthermore, structured rest intervals incorporated into adaptive scheduling models support physical recovery and cognitive restoration, thereby sustaining work capacity under demanding environmental conditions.

Beyond direct health protection, Gómez et al. (2022) indicate that reorganizing working schedules may generate organizational benefits. Reductions in fatigue and physiological stress are associated with improved concentration, fewer operational errors, and enhanced performance outcomes. Flexible scheduling frameworks also enable agricultural tasks to be aligned with meteorological forecasts, facilitating more strategic planning and resource management in contexts of climatic uncertainty.

Nevertheless, the feasibility and effectiveness of rotating working hours in the Ecuadorian agricultural context require careful empirical evaluation. Considerations such as workers' acceptance, potential income implications, operational restructuring costs, and productivity adjustments must be systematically examined before large-scale implementation. Adaptive reforms of this nature demand coordinated engagement among employers, workers, labor authorities, and sectoral representatives (Arellano & Silva, 2020). Without institutional articulation and participatory design, even well-founded measures risk generating unintended economic or social consequences.

Theoretical and Practical Implications of the Research

From a theoretical perspective, this documentary study contributes to the consolidation of an interdisciplinary analytical framework connecting climate change, occupational safety, and labor organization in agricultural systems. By examining how climatic transformations materialize as occupational risks, the research reinforces explanatory models that integrate environmental vulnerability with labor rights and risk governance (Guamán, 2022). Additionally, the analysis of adaptive scheduling strategies advances the conceptual dialogue between occupational risk management theory and climate adaptation frameworks.

From a practical standpoint, the findings offer relevant guidance for the formulation and refinement of public policies aimed at safeguarding Ecuadorian agricultural workers. The identification of principal climate-related occupational hazards, together with the evaluation of adaptive scheduling mechanisms, provides policymakers and sector leaders with evidence-based tools for designing comprehensive interventions. Such interventions must balance worker protection with economic sustainability and sectoral competitiveness. Moreover, the evidence generated may inform agricultural enterprises seeking to adopt resilient organizational models capable of responding proactively to climatic variability (Suárez et al., 2022).

METHODOLOGY

This study was conducted within a critical socio-legal epistemological framework, grounded in the premise that knowledge emerges from the lived social realities of Ecuadorian agricultural workers. The analysis integrates legal, social, environmental, and labor dimensions, recognizing workers not merely as subjects of regulation but as active agents capable of transforming their working conditions. This positioning situates the research within a critical tradition that interrogates structural inequalities and power asymmetries embedded in labor and environmental governance.

The research adopts a qualitative approach based on documentary analysis. A systematic review of secondary sources—including peer-reviewed academic articles, institutional reports, and national and international regulatory frameworks—was undertaken to examine the interrelationship between climate change, thermal stress, and labor rights. The study is exploratory–descriptive and propositional in scope: it characterizes the phenomenon of thermal stress within the Ecuadorian agricultural context while advancing feasible adaptive and preventive strategies aimed at mitigating its effects.

Methodologically, a systematic bibliographic review was conducted using academic databases such as Scopus, Web of Science, and Google Scholar. Priority was given to indexed publications and technical documentation produced by the International Labour Organization (ILO) and other recognized international bodies. The primary analytical technique employed was documentary analysis. Through this process, constitutional provisions (Constitution of the Republic of Ecuador), statutory regulations (Labor Code, Occupational Safety and Health Regulation), supranational instruments (Andean Instrument, Pact of San José), Sustainable Development Goals (SDGs), constitutional jurisprudence, and relevant scientific doctrine were examined to identify applicable principles, rights, obligations, and regulatory gaps.

RESULTS

The systematic review indicates that climate change has substantially altered occupational safety conditions for agricultural workers in Ecuador. Rising temperatures, irregular precipitation patterns, and the proliferation of pests and vector-borne diseases have intensified existing occupational hazards and generated new forms of environmental

exposure. These climatic pressures are associated with increased incidence of heat-related illnesses, respiratory conditions, and psychosocial distress, thereby affecting not only physical health but also emotional stability and labor performance.

The literature identifies rotating work schedules and flexible labor modalities as potential adaptation mechanisms. Limiting exposure to peak radiation periods and restructuring working hours emerge as strategies capable of reducing cumulative thermal load and associated health risks. However, the reviewed evidence also suggests that the effectiveness of these measures depends on contextual variables—including institutional capacity, sectoral organization, and socioeconomic conditions—indicating the need for further empirical validation in the Ecuadorian context.

Additional findings underscore the necessity of a comprehensive and multi-stakeholder adaptation framework. Effective climate adaptation in agricultural workforce management requires the integration of preventive training programs, emergency response protocols, occupational health surveillance systems, and incentive structures that promote workforce stability. Technological innovations—such as wearable monitoring devices, environmental sensors, and mechanization—are identified as emerging tools with potential to enhance sectoral resilience and risk mitigation capacity.

A critical gap identified through the documentary analysis concerns the disconnection between normative frameworks and their effective enforcement. Although Ecuador possesses a robust constitutional and regulatory architecture in occupational safety and health, implementation deficits persist, particularly in rural areas characterized by high informality. Limited labor inspection capacity, insufficient awareness of rights among workers, and the marginal incorporation of thermal stress into formal prevention programs collectively constrain the adaptive capacity of Ecuador's agricultural production system in the face of climate change.

DISCUSSION

Although international organizations such as the International Labour Organization (ILO, 2022, 2023) have identified thermal stress as one of the most significant emerging occupational risks of the twenty-first century in outdoor labor environments, Ecuador has yet to develop specialized public policies that address this phenomenon through an intersectional and adaptive framework. While the Constitution, the Labor Code, and the Occupational Safety and Health Regulation formally recognize the right to safe and dignified working conditions, regulatory implementation remains fragmented, reactive, and insufficiently differentiated across territorial and sectoral contexts.

From a critical standpoint, the concept of the "adaptive working day" represents a theoretically coherent mitigation strategy. However, its practical viability depends on strengthened institutional capacity, technical assistance mechanisms, and sustainable financing structures—particularly in micro and small rural production units, where informal labor predominates and effective State oversight is limited. Empirical findings from Gómez et al. (2023) and Guamán and Stoessel (2022) indicate that a substantial proportion of agricultural workers lack access to basic occupational health services and

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adequate heat-protective equipment. In this context, effective interinstitutional coordination becomes indispensable for guaranteeing labor rights and mitigating risks associated with climatic variability and thermal stress.

The reviewed literature further demonstrates that thermal stress extends beyond physiological harm. In addition to heatstroke, dehydration, and cardiovascular complications, it generates cognitive and psychosocial consequences, including chronic fatigue, anxiety disorders, and diminished productivity (González et al., 2020; IPCC, 2022). Despite this multidimensional impact, the psychosocial dimension remains insufficiently integrated into Ecuador's occupational risk prevention frameworks.

Within this analytical framework, the transition toward a climate-resilient occupational health model becomes imperative. Such a model should integrate:

- Climate-informed schedule rotation aligned with meteorological forecasting systems.
- Systematic training for the early identification and management of thermal stress symptoms.
- Investment in thermal mitigation infrastructure, including hydration stations, shaded rest areas, and specialized protective clothing.
- Continuous environmental and physiological monitoring through wearable technologies (e.g., digital thermometers and humidity sensors).
- Formal recognition of thermal stress within the national registry of occupational diseases.

Simultaneously, strengthening rural labor inspection mechanisms and updating sectoral regulations is essential. Mandatory protocols for managing thermal stress and other climate-related risks must be institutionalized rather than treated as optional or reactive measures. Comparative experiences from tropical countries such as Brazil and Mexico provide valuable policy references for designing context-sensitive regulatory responses.

Equally important is the recognition of agricultural workers as active participants in policy design and implementation. Promoting social dialogue, strengthening rural unions, and engaging organizations within the popular and solidarity-based economy fosters collective ownership of adaptive strategies. Such participation enhances policy adherence and contributes to long-term sustainability. An intersectional and adaptive approach is not merely normative; it is structurally necessary. By acknowledging pre-existing inequalities and rejecting uniform regulatory solutions, public action can be recalibrated to address differentiated vulnerabilities in the context of climate change.

The findings of this research underscore the intricate relationship between climate change, occupational safety, and labor organization within Ecuador's agricultural sector. Climatic pressures are not peripheral stressors; they are structural determinants reshaping risk exposure and health outcomes for rural workers. Consequently, mitigation strategies cannot remain isolated within regulatory texts but must translate into enforceable, coordinated, and contextually grounded action.

The rotation of working schedules emerges as a promising adaptive measure. Nevertheless, its effectiveness is contingent upon socioeconomic feasibility, institutional

commitment, and sustained policy support. Adaptive scheduling, when embedded within broader structural reforms—including training systems, emergency protocols, technological monitoring, and interinstitutional collaboration—constitutes part of a multifaceted response to climate-induced occupational risk.

Ultimately, addressing the occupational health impacts of climate change in Ecuador requires moving beyond declarative regulation toward operational governance. Only through coordinated institutional action, evidence-based policy design, and meaningful worker participation can the agricultural sector achieve sustainable adaptation while safeguarding the dignity, health, and productivity of its workforce.

CONCLUSION

In alignment with the general objective of this study, the findings demonstrate that climate change constitutes a progressively intensifying threat to the occupational safety and health of Ecuadorian agricultural workers. The emergence of thermal, biological, and psychosocial risks—particularly those associated with prolonged heat exposure—redefines the landscape of occupational vulnerability in rural environments. Thermal stress, as a structurally embedded and escalating risk, demands prioritized attention within normative, technical, and preventive frameworks.

Regarding the specific objective, the analysis confirms that the adaptation of working hours represents a viable and strategically significant response to extreme heat exposure. However, its effectiveness is contingent upon comprehensive and context-sensitive implementation. Adaptive scheduling must be supported by sustained public policies aligned with the diverse climatic realities of Ecuador's regions, ensuring that interventions are territorially differentiated rather than uniformly applied.

The findings further underscore the necessity of integrating complementary adaptive measures. These include systematic training on climate-related occupational hazards, improvements in workplace infrastructure, deployment of environmental and physiological monitoring technologies, strengthening of rural labor inspection mechanisms, and expanded access to occupational health services. Such measures collectively reinforce institutional capacity to respond proactively to climate-induced risks.

Ultimately, meaningful adaptation of Ecuador's agricultural sector to climate change requires a holistic governance approach that integrates technical innovation, organizational reform, and social participation. The protection of workers' health, the safeguarding of rural labor dignity, and the long-term sustainability of agricultural production depend upon coordinated action among State institutions, employers, workers, and the scientific community. Without such articulation, regulatory recognition will remain insufficient to confront the structural transformations imposed by climate change.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.