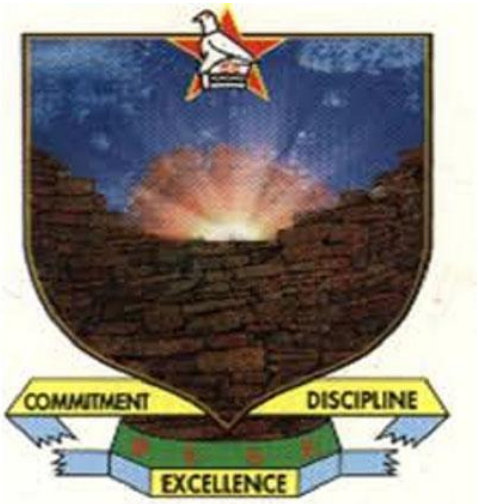
BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE

DEPARTMENT OF ENVIRONMENTAL SCIENCE

Geospatial analysis of occupational heat stress and healthcare accessibility for agricultural workers at east range sd3 farm.



Magaya Liliosa

(B241743B)

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS OF MASTER OF SCIENCE IN OCCUPATIONAL HEALTH, SAFETY AND ENVIRONMENTAL MANAGEMENT

May /2025

Dedication

This dissertation is dedicated to my family, my husband, and my parents for supporting me throughout this journey and giving me the courage to continue and not give up.

Acknowledgments

I would like to express my sincere gratitude to my supervisor, Dr Dudu, for the valuable guidance, patience, and feedback. In addition, grateful to the management and workers of the East Range farm for their cooperation during data collection. My appreciation also goes to my classmates who contributed to the successful completion of this study.

Abstract

This study assessed occupational health and safety (OHS) risks, heat exposure, and socioeconomic vulnerabilities among agricultural workers at a large-scale commercial farm in Sebakwe, Zimbabwe. A mixed-methods approach was employed, combining structured questionnaires administered to 34 farm workers and semi-structured interviews with one manager and five supervisors. Also, geospatial tools and techniques were used for spatial risk assessment. The findings from the Interview revealed the absence of formal occupational health and safety (OHS) systems, with most safety practices being informal and inconsistently applied. Workers reported limited safety training, inadequate use of personal protective equipment (PPE), and significant exposure to agrochemicals without proper protocols. Wet Bulb Globe Temperature (WBGT) analysis across 2024 showed that over 53% of days were in the moderate to extreme heat stress range, with 3.3% exceeding critical thresholds (≥32°C), particularly in the northern, less-shaded zones of the farm. Socioeconomic analysis indicated disparities between permanent and non-permanent workers, with the latter experiencing lower education levels but fewer dependents, while permanent workers faced greater financial strain due to larger household sizes and injury-related costs. Healthcare accessibility was a challenge, with many workers residing over 10 km from health centres, hindering timely medical attention. This highlights systemic gaps in occupational safety governance and emphasises the need for formalized health and safety protocols, improved training, and adaptive measures to protect farm workers from environmental and occupational hazards in the context of climate stress. Also crucial to address inequities faced by non-permanent workers by expanding their access to healthcare, education, and formal employment protection. Despite being confined to a single farm, the study offers crucial insights into systemic issues, urging policymakers and farm management to prioritize agricultural workers. Ultimately, protecting farm workers is essential for fostering a more sustainable and equitable agricultural system aligned with several United Nations Sustainable Development Goals.

Table of contents

List of Tables

List of Figures

LIST OF ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographic Information System
ILO	International Labour Organization
LDCs	Least-Developed Countries
MSDs	Musculoskeletal Disorders
OHS	Occupational Health and Safety
PPE	Personal Protective Equipment
SDGs	Sustainable Development Goals
UN	United Nations
WBGT	Wet Bulb Globe Temperature

CHAPTER 1: INTRODUCTION

1.1: Introduction

Agriculture remains an important sector in the economies of many countries around the world, particularly in developing regions and least-developed countries LDCs, where it is considered a cornerstone for economic growth. (Food and Agriculture Organization of the United Nations, 2001). In Zimbabwe, agriculture is the backbone of livelihoods and food security. It serves as the main source of income for the majority and as a way of alleviating poverty and integrating into the global economy. However, agricultural workers, particularly those in rural areas, are greatly affected by occupational health and safety risks due to the physical nature of their work during the peak months of planting and harvesting, prolonged exposure to harsh environmental conditions, limited access to healthcare services, and various socioeconomic challenges. The occupational health and safety of these workers is thus a critical issue that requires innovative strategies that ensure the protection of the farm workers (ILO, 2024).

As global climate change intensifies, temperature variability has become a pressing environmental concern for agricultural workers. Most regions are increasingly experiencing extreme temperature fluctuations, including rising temperatures and more frequent heat waves. In relation to agricultural workers, prolonged exposure to extreme temperatures can lead to heat-related illnesses such as heatstroke, dehydration, and long-term cardiovascular problems (Hamed et al., 2018). According to Kjellstrom et al. (2016), global warming is expected to increase the occurrence and intensity of extreme heat events, disproportionately affecting outdoor labourers in agriculture. These workers are vulnerable to heat stress, which not only threatens their health but also reduces their capacity to perform labour-intensive tasks, thus impacting productivity and economic stability.

In remote areas of Zimbabwe, the healthcare system is also strained by socioeconomic determinants like underfunding and shortages of medical practitioners and medical supplies (Mangundu, 2020). This means that even after accessing healthcare facilities, there is a high probability that the quality of care could be poor. Such inaccessibility and poor condition of

healthcare infrastructure make agricultural workers vulnerable to the risk of untreated injuries, uncontrolled chronic diseases, and the compounding effect of temperature-related health risks.

The occupational health and safety of agricultural workers is also heavily affected by socioeconomic levels. In most remote areas, like the East range farm, most agricultural workers are part of low-income households with limited exposure to education, health, and social protection services. It also increases their exposure to health risks since they might not have the means to afford protective equipment, transport to health facilities, or even time off from work to visit a doctor. This is supported by the vulnerability theory, which explains that people with lower socioeconomic status are also more at risk of being harmed since they have fewer buffers to shield them from risks and react to negative health consequences. (Turner et al., 2003)

Additionally, only agricultural workers are protected by national laws, employment injury benefits, or insurance schemes, usually, they are employed in non-regulated or informal environments, where labour protection and safety conditions are weak or non-existent. Strong enforcement is poor due to a shortage of labour inspection, no understanding and training on hazards and their prevention, and low organizational levels among farming workers. The absence of regulation increases the risk of hazardous working conditions, for instance, exposure to pesticides, unsafe equipment, and inadequate rest periods, especially during the height of heat waves. Addressing the socioeconomic determinants that impact the occupational health of farmers is essential, as poverty and limited access to relief services can hinder their ability to defend their rights and access necessary healthcare. This challenge has prompted the development of innovative tools aimed at clinically evaluating the complex tasks and occupational health and safety hazards associated with farm work.

Geographic Information Systems (GIS) and remote sensing technologies offer powerful methods for the comprehensive analysis of the spatial and environmental factors influencing these risks. GIS facilitates the mapping of facilities, transportation routes, and agricultural areas, while also providing specific better understanding of how spatial accessibility to healthcare impacts worker health outcomes. This data enhances our understanding of how geographical access to medical care affects worker health outcomes. In contrast, remote sensing allows for the monitoring of land use and temperature fluctuations, which can

indicate environmental conditions that elevate health risks due to excessive heat. This research will utilize both GIS and remote sensing to analyze how temperature variability influences access to health care and the socioeconomic factors that affect the occupational health and safety of workers at East Range Farm in Kwekwe.

The study aims to bridge existing gaps by synthesizing geospatial data with qualitative insights to address the evaluative deficiencies in research related to environmental and socioeconomic factors that assess occupational risk exposure to agricultural hazards. Furthermore, it seeks to identify promising interventions that can enhance health and safety outcomes for these workers. This research aligns with the global agenda for sustainable development and contributes to several United Nations Sustainable Development Goals (SDGs), including SDG 3 (Good Health and Well-Being), SDG 8 (Decent Work and Economic Growth), and SDG 13 (Climate Action).

1.1.1:Background of study

Agricultural workers are continuously exposed to hazardous working conditions that undermine their occupational safety and health. Among these risks, extremes of heat and cold, especially excessive heat, have been a prime issue due to the physically demanding and outdoor nature of farm work. East Range SD3 Farm, for instance, farm workers often work outdoors with no shade and sometimes no protective equipment, where temperatures at the height of the farming seasons record 30°C, and in extreme situations above 40°C, particularly during dry years. The climatic background of the area also enhances these risks. The region has a hot, humid summer season between mid-November and mid-March, which coincides with the intensive planting and harvesting schedule. Average maximum temperatures of 28°C to 31°C for the duration, combined with high humidity levels, augment the impacts of heat stress.

Although the cool, dry winter months (May to August) bring some respite, the hot, dry pre-rainy months (September to November) are the most thermally stressful. These difficulties are compounded by climate change, which has caused a rising frequency and severity of heat waves. Consequently, workers are exposed to greater risks of heat-related illnesses, such as heatstroke, dehydration, and chronic cardiovascular consequences (McMichael et al., 2017). Additionally, restricted access to health care because of geographic location and affordability

increases the risks of illness and injury, making it difficult to treat injuries and illnesses effectively (Méndez-Lázaro et al., 2018).

Many studies have been done on the topic of occupational health and safety risks faced by agricultural farm workers, including exposure to extreme heat and hazardous conditions. Research by Xiang et al. (2014) highlights the growing number of heat-related illnesses in the U.S, pointing out that workers working in extreme heat have high chances of experiencing heat stroke and cardiovascular issues, but few studies have investigated the integration between environmental exposure and healthcare accessibility in Zimbabwe or Sub-Saharan Africa. Likewise, Kjellstrom et al. (2016) stated that global warming is worsening these conditions, disproportionately impacting workers in tropical and subtropical areas. However, the literature to date mostly deals with singular individual risk factors, like temperature exposure or workplace injury, in isolation from the local spatial context, such as access to healthcare.

Despite the widely reported climatic stressors, farm workers and seasonal workers are commonly confronted with substantial barriers to accessing healthcare, such as geographic location, cost, and unavailability of services (Arcury & Quandt, 2007). GIS is particularly useful for analyzing spatial patterns in occupational health by mapping healthcare facilities, transportation networks, and environmental conditions affecting worker safety. Ricketts' (2014) and Sallis et al.'s (2018) studies highlight the spatial access aspect, revealing that rural populations residing in sparsely populated areas experience worse health outcomes because of their low degree of proximity to health facilities.

In addition, socioeconomic conditions increase farm workers' vulnerability as most are informal or seasonal workers, with limited levels of exposure to protection by safety precautions, training, and health care. Also, a lack of legal protection leads to insufficient reporting, response, and remediation of work hazards. There are reported health inequities between farm workers and other industries, with farm workers experiencing increased rates of injury, heat-related illnesses, and long-term chronic conditions (Stoecklin-Marois et al., 2017). Socio-cultural beliefs and social norms also affect health-seeking behavior, with normalisation or underreporting of the symptoms of heat stress or injury, so that medical services are sought out later when conditions are critical. Technological barriers in the form

of the availability of mobile health systems and environment monitoring systems for real-time exposure assessment also hamper the scope of adaptive safety solutions. Finally, psychosocial stressors of unemployment, economic poverty, and social isolation increase the overall healthcare burden of such populations.

This research is based on several theoretical foundations. Firstly, Occupational Health and Safety (OHS) Theory requires the identification of workplace hazards and the adoption of controls to reduce their effects on the health of workers. OHS theory will be the foundation for comprehension of temperature fluctuation risk and restricted access to health care in agriculture (Zhou et al., 2015). Climate Change and Environmental Stress Theory is one of the key theories describing how temperature changes and heat extremes are environmental stressors jeopardizing workers' health. Global warming creates hazardous working conditions for outdoor workers, and the theory is applied to place the effects of such changes, as proposed by Kjellstrom et al. (2016). Spatial Accessibility and Healthcare Utilization Theory focuses on how health outcomes are influenced by geographic distance and accessibility to healthcare services.

Ricketts' (2014) studies have confirmed that people residing far from healthcare facilities are less likely to seek early medical care, and this results in poor health outcomes. This is the theory that supports GIS for health care access analysis and demonstrates the utility of these maps to understand geographical proximity on health care utilization in the rural farming worksite. In addition, vulnerability theory can help us understand the susceptibility of different groups, like rural farmworkers, to environmental and occupational risks because of their status and their geographical location (Turner et al., 2003). It focuses on selective interventions used to reduce susceptibility and improve health effects. Although Geographic Information Systems (GIS) and remote sensing continue to expand in popularity in the field of public health and environmental literature, limited literature exists for fields such as occupational safety and health. Previous studies identified pesticide exposure (Stoecklin-Marois et al., 2017) or environmental (Bauer et al., 2020) issues, but few tried to relate to workers' health or accessibility to health care issues. Therefore, this study uses GIS and remote sensing to conduct an integrated spatial analysis of temperature variability and healthcare access to farmworker health and safety.

This research contributes to existing literature by providing further data on the application of spatial tools in the field of occupational health and safety of workers by demonstrating how GIS and remote sensing can be applied to assess health hazards effectively. The study aims to conduct a geospatial analysis of occupational heat stress and healthcare accessibility for agricultural workers, which offers a more comprehensive picture of the determinants of worker vulnerability. The findings can be valuable to policymakers, farm managers, and public health practitioners, enabling the development of evidence-based interventions that increase access to healthcare, enhance work safety, and aid in climate resilience planning for vulnerable rural working populations.

1.2: Problem statement

Due to environmental and socioeconomic factors, many of the agricultural workers, both small-scale and large-scale, in Zimbabwe's Midlands Province are at risk of health and safety issues, particularly due to environmental and socioeconomic factors. The leading concern is the exposure to extreme temperature fluctuations caused by climate change, which increases the likelihood of heat illnesses such as dehydration and heatstroke. These risks are exacerbated by limited access to healthcare because most of the agricultural workers live in remote areas with poor transportation infrastructure, making it difficult to access timely medical care. In addition, environmental factors, socioeconomic challenges like poverty, and informal work further increase the vulnerability of the workers. Most do not have the means to provide protective equipment, healthcare, and transportation, so they are prone to occupational injuries and long-term health issues. Despite attempts to expand access to primary care facilities in remote areas of Zimbabwe, there exist huge disparities, particularly for rural farmworkers.

Numerous empirical studies demonstrate the intricate relationship between environmental, spatial, and socioeconomic factors because of the complexity of these indicators and their interactions. These variables are essential for assessing risks related to workers' occupational health. Poor distribution of healthcare facilities and poor health insurance coverage of self-employed workers are among the contributing factors towards these factors, which relate to high injury and illness rates. The study aims to bridge these gaps by employing Geographic Information Systems (GIS) and remote sensing in examining how temperature variability,

access to healthcare, and economic status intersect in influencing the well-being and safety of Midlands Province farm workers. The findings will have policy recommendations for stakeholders, with the focus on how best to expand healthcare access and minimize health hazards for farm workers. The study will also evaluate how well current policies work and provide suggestions to erase health disparities and improve the well-being of this vital workforce.

1.3: Research Aims

The aim of the study is to assess the OHS risks faced by agricultural workers on the East range SD3 farm in Kwekwe, focusing on the interplay between temperature variability, healthcare accessibility, and socioeconomic factors.

1.4: Research Objectives

The specific objectives are:

1. To assess the occupational health and safety issues that farmers and farm workers are exposed to in the agricultural industry.
2. To measure and identify the temperature variability patterns at the East range SD3 farm
3. To assess healthcare accessibility and availability of healthcare services support for agricultural workers at the East Range SD3 farm
4. To investigate the socioeconomic factors influencing occupational health and safety risks among agricultural workers at the East Range SD3 farm.

1.5: Research Questions

1. What are the occupational health and safety risk concerns for agricultural workers?
2. What is the extent of temperature variability in the case study, and how does it affect the health and safety of agricultural workers?
3. Are health services available and accessible for agricultural workers near the study area, and what are the implications for the health and safety of workers?
4. What are the socioeconomic conditions of agricultural workers in Zimbabwe, and how do they contribute to their vulnerability to OHS risks?

1.6: Delimitations of the Study

1. Sample size: The sample size of agricultural workers included in the study may limit the generalizability of the findings. Only farm workers and management from East Range SD3 Farm were included.
2. Geographical scope: The study will focus on a large-scale farm, and the findings may not be directly applicable to other countries with different agricultural conditions. The study focuses exclusively on East Range Sd3 Farm in Kwekwe, Midlands Province, Zimbabwe. It does not assess OHS risks in other farms, even within the same province.
3. Scope of Analysis: This study assesses OHS risks specifically related to heat stress, healthcare access, and socioeconomic factors using GIS and remote sensing. Other occupational risks, like pesticide exposure, ergonomic injuries, or infectious diseases, are acknowledged but not deeply analyzed.
4. Methodological Boundaries: The study employs a mixed-methods approach but relies heavily on self-reported data through questionnaires and interviews, which may be subject to perception bias.

1.7: Limitations of the study

1. Size Constraints: With a sample of only 30% participants for both permanent and non-permanent workers, findings may not be statistically generalizable across the entire farm or to other farms.
2. Data Availability and Accuracy: Access to high-resolution, real-time satellite data and historical temperature trends may have been limited. Similarly, healthcare access data may not reflect emergency services or informal care providers.
3. Time frame: The study will be conducted within a specific time, and the findings may not reflect changes that occur over time. The study is limited to a specific data collection window within a single year, which may not fully capture seasonal changes or long-term trends.

4. Self-Reporting Bias: Responses from farm workers and supervisors may be affected by recall bias, fear of employer reprisal, or misunderstanding of questions, which could impact the reliability of the data.
5. Limited Local Records: There is a lack of detailed, officially recorded data on workplace injuries or illnesses at the farm, limiting the validation of self-reported data.
6. Technological and Infrastructure Gaps: Limitations in GIS data coverage (e.g., outdated road networks or healthcare facility locations) and a lack of local meteorological stations could affect spatial accuracy.
7. Generalizability: Due to its localized focus, findings may not apply to farms in different regions with different climatic, regulatory, or infrastructural conditions.

1.8: Justification of the study

Occupational health and safety (OHS) risks among agricultural workers remain a significant concern globally, yet there is a lack of systematic research in Zimbabwe to quantify and address these risks. The agricultural sector employs over 1.3 billion workers worldwide, making it one of the most hazardous industries due to extreme environmental conditions, exposure to chemicals, and the absence of adequate workplace protections (ILO, 2024). Despite its economic importance, Zimbabwe's agriculture sector remains understudied in terms of occupational hazards, particularly temperature variability and healthcare accessibility, which are key determinants of worker health and productivity. Existing research focuses on isolated risk factors such as heat stress or workplace injuries without integrating them with spatial and socioeconomic dimensions. This study seeks to bridge this gap by employing Geographic Information Systems (GIS) and remote sensing to assess how temperature variability, healthcare accessibility, and socioeconomic factors impact farmworkers in Midlands Province.

With climate change intensifying, agricultural workers face prolonged exposure to high temperatures, leading to heat-related illnesses such as dehydration, heat stroke, and cardiovascular disorders (Kjellstrom et al., 2016). The ILO (2024) confirms that climate variability is worsening the working conditions of farm workers, particularly in developing countries, where access to healthcare remains poor. Zimbabwean agricultural workers often

operate in remote locations with limited access to primary healthcare services, increasing their vulnerability to untreated injuries and chronic health conditions (Méndez-Lázaro et al., 2018). Furthermore, inadequate recording and notification systems result in underreported workplace accidents and illnesses, making it difficult to develop effective interventions (ILO, 2024, p. 17). Furthermore, the ILO (2024) highlights that agricultural workers, especially seasonal and informal labourers, often lack legal protections, social security, and employer-provided safety measures. Many workers face poverty and job insecurity, making them more susceptible to occupational risks (Turner et al., 2003). Without targeted policies addressing these challenges, OHS conditions in the sector will continue to deteriorate.

This study is one of the first in Zimbabwe to integrate geospatial analysis into occupational health research, providing data-driven insights to help policymakers design better healthcare access strategies and workplace safety regulations. By mapping temperature exposure levels and healthcare service availability, the study will identify high-risk areas and propose interventions to mitigate health risks for farm workers. The findings will be crucial for policymakers, occupational health practitioners, and farm management in developing targeted interventions that ensure a safer and healthier agricultural workforce. Moreover, this research contributes to global discussions on occupational health in agriculture by demonstrating how GIS and remote sensing can be used to assess spatial disparities in healthcare access. It aligns with ILO recommendations on improving safety and health standards in agriculture and will provide a framework for future research and policy implementation in similar agrarian economies.

CHAPTER 2: LITERATURE REVIEW

This chapter examines the published information about occupational health and safety (OHS) risks faced by agricultural workers and the importance of understanding socioeconomic and environmental factors in the sector. The review will encompass the global, regional, and local

research to understand OHS hazards in the agricultural sector, particularly heat stress and health care accessibility for agricultural workers in Zimbabwe.

2.1: Occupational Health and Safety (OHS) Theory

Agriculture is considered one of the most hazardous industries in the world, with a workforce estimated at about 1.3 billion, as reported by the International Labour Office report (ILO, 2000). Agriculture faces several occupational risks, including machinery injuries, pesticide poisoning, and other agrochemical-associated dangers (ILO, 2000). Work mortality rates in agriculture have been high in the last decade, and millions of workers have been injured in occupational accidents (ILO, 2024). Most agricultural workers in developing countries are victims of the green revolution and globalization trends (ILO, 2024). Women and children are the ones who suffer the most, especially with issues like heavy workloads, poor working conditions, and inadequate access to health care (ILO, 2024). The International Labour Organisation has ratified several conventions and recommendations related to agricultural occupational health and safety, including the Plantations Convention 110, 1958, and the Occupational Safety and Health Convention 155. (ILO, 2024). Although the aim is to protect workers from occupational hazards and promote safe working conditions in agriculture. The countries that have ratified ILO conventions addressing agricultural occupational health and safety as of March 2000, including Zimbabwe, struggle to implement and enforce these conventions. (ILO, 2024).

Similarly, Galvis (2023) further supports the findings from the ILO about the high risks and dangers of agriculture and the need to manage risks to prevent injuries and illnesses while ensuring productivity improvement, better farming practices, reduced production, and reduced output loss. In addition, the results of the study highlight that in South America, agriculture incidents have the highest accident rate, accounting for 78.1% of all occupational accidents, according to the International Labor Organization. The study highlights the critical role played by technology, education, and public awareness in enhancing occupational safety and health in agriculture, proposing that government agencies must lead interventions, supported by academic institutions, to come up with measures that mitigate OHS risks.

Furthermore, an extensive study by Matabanchoy-Salazar (2021) noted that approximately 6,300 deaths occur daily, nearly 2.3 million annually, with more than half of the 321,000 fatal accidents attributed to agriculture. In California alone, over 3,000 agricultural workers report back injuries, with worker compensation costs exceeding $22 million annually, and many injuries likely go unreported (Instituto Nacional para la Seguridad y Salud Ocupacional, 2022). Narváez-Chaves et al. (2024) discovered that in Colombia, during the first half of 2020, there were 211,055 occupational accidents, with 13% related to agriculture, livestock, hunting, and forestry. This sector exhibited the highest accident rate at 6.8 incidents per 100 workers. Of 6,074 recorded occupational diseases, 353 were in agriculture, making up 6%. These statistics align with findings in South America, where agriculture was observed to have the third-highest accident rate, with an estimated incidence of 10.7 accidents per 100,000 people. Additionally, a report on occupational accidents highlighted that the South American agricultural sector had a 78.1% accident rate, with 48 fatalities from occupational incidents in 2019, leading to 1.2 million lost workdays (Galvis, 2023).

Despite alarming figures, addressing occupational safety and health challenges in the agricultural sector is hindered by several factors. These include inadequate labour laws, insufficient enforcement, and a lack of skilled personnel to implement improvements. Additionally, workers' limited knowledge of their rights and responsibilities, coupled with high illiteracy rates, complicates the implementation of safety standards. Geographical constraints also impede access to some workplaces and healthcare facilities, further exacerbating the issue. (Shabani et Al., 2023)

2.2: Hazards faced by agricultural workers.

As reflected in the report published by SafeWork, ILO (2000), farmers are vulnerable to both fatal and non-fatal injuries, with exposure to pesticides and other agrochemicals being a significant occupational risk that could lead to poisoning, death, and, in some cases, work-related cancers and reproductive issues. Agricultural workers face numerous hazards, including machinery accidents, exposure to hazardous chemicals and pesticides, and

infectious diseases. They are also at risk from ergonomic hazards, extreme temperatures, and encounters with wild and poisonous animals. These hazards pose significant threats to their health, safety, and well-being. However, official data on occupational accidents and diseases is imprecise due to inadequate recording and notification systems. Only a few fatal accidents are reported, ignoring nonfatal and minor injuries. Under-reporting is particularly evident in the agricultural sector, where reporting and compensation systems may exclude certain categories.

Research by scholars like Cliff (1981) notes that the agricultural industry faces occupational hazards due to mechanization and increased pesticide control technology. Accidents can result from systemic chemical poisoning and infectious and non-infectious diseases. Prevention is crucial in the industry, with the Health and Safety Executive's Agricultural Safety Inspectorate focusing on education and persuasion. Joint Farm Safety Committees, consisting of employers, employees, and Agricultural Safety Inspectorate representatives, are common in many countries. These committees organize preventive programs to address specific accident problems and reduce agricultural industry issues, but individual responsibility remains. This is important as the farm is 50 to 750 hectares of land that is characterized by advanced mechanized agriculture with significant use of chemicals, intensive and extensive industrial agriculture, cattle raising, national and international marketable production farms. (ILO, 2000)

Nguyen et al. (2018) observed that multiple exposures to occupational hazards such as heat stress, agrochemical exposure, and biomechanical strain contribute to long-term health risks for farm workers. In Zimbabwe, these hazards are amplified by the country’s reliance on intensive pesticide use and minimal workplace monitoring, leading to high incidences of respiratory illnesses and musculoskeletal disorders. Therefore, there is a need for more studies to be conducted to understand the challenges and come up with mitigation strategies.

2.2: Temperature variability and occupational health risk

2.2.1: Heat Stress and Health Risks Among Farmworkers

Heat stress has been identified as one of the crucial OHS stressors for outdoor farmers. The research by Pradhan et al. (2020) highlights various health issues, such as heat-related

illnesses and kidney diseases, to are prevalent among agricultural workers. The study employed a mixed methods approach, incorporating both survey data and medical records analysis to assess the prevalence and impact of these issues. Factors such as prolonged exposure to high temperatures, physical activities increase these health risks. The research underscored the vulnerability of farm workers to heat stress, as many lack sufficient shade and cooling facilities. The researcher suggested providing adequate hydration, rest breaks in shaded areas, and training on the symptoms of heat stress. Thus, providing valuable suggestions that can be helpful if considered by farm employers and farmers.

In addition, research conducted by McCarroll, Hamann, and Reis (2018) identified an important reactive response where farm workers in the Mediterranean region reduce work hours during hot days to avoid any risks. This proved to influence labour productivity and economic challenges, highlighting problems for farm management. However, sometimes employees have no power to change work schedules, and balancing profitability and safety health becomes a challenge for most agricultural farmers. Therefore, there is a need to further understand the measures that can be implemented to reduce occupational and environmental risks, considering the importance of productivity in large-scale commercial farms.

Morabito et al. (2019) also contributed valuable insight on the focused-on interventions to increase resilience against occupational heat stress among outdoor workers with a mixed methods approach in Italy. The findings illustrate the impacts of heat-related problems and the importance of protective measures, including PPE use and modifying the work environment. However, despite providing solutions on the ground, the study does not address issues like policy gaps and socio-economic disparities that derail similar interventions in developing countries. Therefore, there is a need for the incorporation of technologies and considering issues of socioeconomic determinants, a key objective of the current paper.

2.4: Geospatial Analysis of Temperature Variability

Geospatial analysis is an important tool for understanding occupational health and safety (OHS) risks among agricultural workers vulnerable to the dangers of temperature extremes. Analysing spatial data allows researchers to identify patterns, trends, and relationships between environmental factors, socio-economic factors, and health hazards. In addition, helps

identify hotspots and vulnerable populations, providing insights on the challenges faced by farm workers, crucial information for formulating interventions and policies.

The Wet-Bulb Globe Temperature (WBGT) index is a widely used measure of environmental heat stress, integrating temperature, humidity, wind speed, and solar radiation to provide a more accurate measure of heat stress than air temperature alone (Golbabaei et al., 2015; Lemke & Kjellstrom, 2012). For areas remote and large-scale where ground-based data is not available, an alternative WBGT formula can be used, estimating WBGT using satellite or reanalysis data (e.g., ERA5 or NASA POWER). This formula uses air temperature and water vapor pressure to approximate WBGT:

$$WBGT = 0.567T + 0.393e + 3.94,$$

Where T is air temperature (°C) and e is water vapor pressure (hPa) calculated from relative humidity and temperature (Epstein & Mora,n, 2006; Hajizadeh et al., 2015). In the case of Zimbabwe, where temperatures frequently exceed 40°C during peak farming seasons, using satellite-derived WBGT estimates can provide real-time observation and pre-emptive identification of heat stress risks in agricultural zones. While studies conducted in Brazil and India have used this approach to predict workers' health outcomes and inform interventions, large gaps in such detailed, geo-specific heat stress modelling in the agriculture sector in Zimbabwe are limited (Hajizadeh et al., 2015). This means spatial variations in heat exposure and direct impact on health in Zimbabwe in connection with socioeconomic vulnerabilities need more attention. Therefore, this study's approach to modelling temperature variability and its impact on farm workers in Zimbabwe's Midlands province is crucial for generating actionable data for targeted OHS interventions.

2.4: Geospatial Analysis of Healthcare Accessibility

Access to health care is a critical component of Occupational Health and Safety (OHS) because it determines the ability of workers to receive timely and appropriate medical care. Health care services are not always readily available to farm workers living in rural areas, thus potentially contributing to more health-related challenges and reduced overall well-being. The spatial distribution of healthcare centers and their accessibility can help identify the need for service gaps and required focused interventions.

2.5: Impact of Limited Healthcare Access on Agricultural Workers

Limited healthcare access can significantly influence the health and safety of agricultural workers. Agricultural workers are most likely exposed to unhealthy working conditions, poverty, and weak support systems. This can lead to serious health issues such as diabetes, malnutrition, depression, substance use, infectious diseases, pesticide poisoning, and injuries from physical stress and workplace machinery. All these complications can reduce productivity, threaten food security, and economic development (Pradhan, Sahoo, & Kumar, 2020).

Buffering and GIS-based methods have already been successfully applied in several studies to estimate the availability of onsite health care. For example, a study in Ghana used buffer and distance analyses to evaluate accessibility to healthcare services, revealing significant disparities in healthcare accessibility (Moyo et al., 2017). Similarly, a study in Sub-Saharan Africa compared different methods to estimate accessibility to health services and found that simple Euclidean distance methods, such as buffering, perform well in rural areas (Bihin, De Longueville, & Linard, 2022). These studies demonstrate the application of buffering methods in analysing healthcare accessibility, which is particularly relevant to my research question.

While the studies differed in their specific methods and contexts, they demonstrated the effectiveness of geospatial analyses. However, the studies relied on secondary data sources rather than non-spatial variables, such as socioeconomic status and qualitative data, which can limit the generalizability of their findings. However, the studies provide enlightenment on this method that can be built into my research to address the specific accessibility and effectiveness of the provision of health care to remote populations, crucial for interventions. Applying these approaches can assist in clarifying challenges at the farm can provide insight into which farmworkers experience the greatest delays in healthcare access due to transport infrastructure limitations and facility distribution patterns.

2.6: Socioeconomic Factors in OHS

Socioeconomic factors such as poverty, education, and employment status influence the health and safety of agricultural workers. Workers in poverty-stricken areas often lack access

to proper safety equipment and healthcare services, heightening their risk of injuries and illnesses. Reduced awareness of safety practices and health risks, and personal protective equipment has been associated with less education, training on health hazards, leading to poorer OHS outcomes. (Pradhan, Sahoo, & Kumar,2020. Understanding these factors through geospatial analysis allows for targeted interventions and policies to improve the well-being of agricultural workers.

2.7: Relationship between Socioeconomic Factors and OHS

These socioeconomic factors influence workers' access to PPE, healthcare services, and their overall health conditions. Having knowledge of the spatial distribution of these socioeconomic determinants can help identify vulnerable populations and develop targeted interventions. Research has shown that socioeconomic conditions are strongly linked to health outcomes. For example, research on the relationship between socioeconomic conditions and health status in the Twente region of the Netherlands found that areas with lower socioeconomic status have poorer health outcomes and higher healthcare costs (Neziri, 2022). This underscores the necessity for targeted public health initiatives that address the socioeconomic determinants of health.

Turner et al. (2003) conceptualize the vulnerability theory as central to the explanation of how socioeconomic disparities shape health risks. Also, seasonal or informal workers with no health insurance and stable employment are vulnerable to most of the challenges. Evidence in Sub-Saharan Africa indicates that lower education levels and poverty correlate strongly with reduced healthcare access and increased workplace injuries (Nsiah et al., 2024). These results highlight the necessity of targeted interventions that address both economic insecurity and occupational health in rural Zimbabwe.

This chapter highlights some of the occupational health risks among farmers, including heat stress and limited healthcare access. Despite the recognition of the above challenges, there still exist literature gaps in using a holistic approach that measures these challenges within the context of the Zimbabwean agricultural sector. Understanding these challenges is important for implementing interventions further explored by this research.

CHAPTER 3: RESEARCH METHODOLOGY

3.1: Study area description

East Range SD3 farm, situated in Zimbabwe's Sebakwe Recreational Park i is located 66km away from Kwekwe, situated -19.0617149 latitude and 30.2190314 longitude. The range altitude is 1,292.0708365 above sea level. The area is known for its diverse geomorphology and rich biodiversity, which is crucial for agricultural practices and crop selection. The warm climate, with significant seasonal variations, influences crop selection and irrigation capabilities. The farm's predominant soil types are sandy loam and clay loam, known for their excellent drainage and nutrient content. To optimize agricultural output, Ethe ast Range SD3 farm employs key practices such as crop rotation, intercropping, and organic farming. The farm cultivates a variety of crops, including winter wheat, potatoes, and maize, with 900 hectares allocated for winter wheat and 80 hectares for potatoes ,depending on the seasons. Over 2,000 cattle are raised on the farm, which integrates crop and livestock farming for a holistic approach to agricultural production.

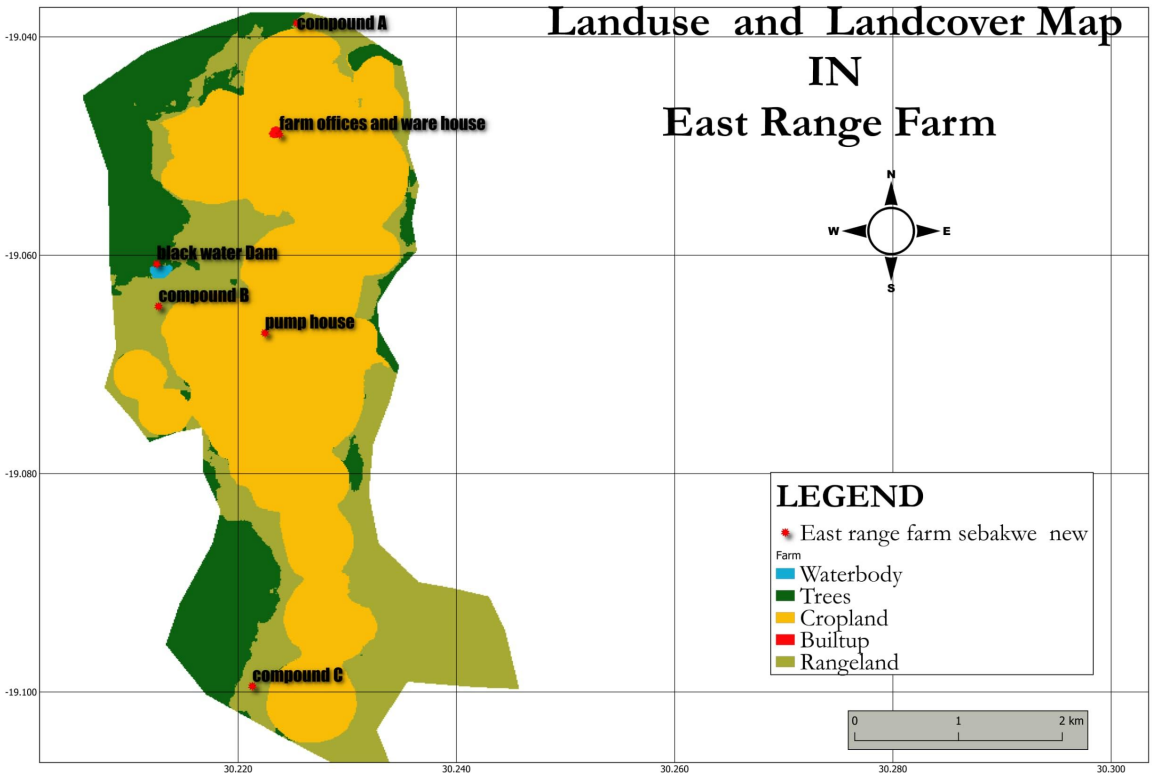


FIGURE 3.1 :STUDY AREA MAP

3.2: Research Design

The research employs a mixed-methods approach with quantitative and qualitative data. The quantitative approach utilizes geospatial analysis and questionnaires with farm workers, while the qualitative component includes interviews with managers and supervisors. The approach makes it easy to understand the OHS risks and the factors influencing the farm workers at the farm.

3.3: Sampling Strategy and Target Population

The study population consists of 120 workers employed at the farm, both permanent and non-permanent. These groups include farm workers, livestock handlers, and farm manager supervisors. These participants conduct different tasks including planting, weeding, harvesting, irrigation, pest control, and. machinery operation. Additionally, these workers are responsible for animal care, monitoring health, and managing herds, all under the guidance of

farm management and supervisors. The farm manager and supervisors oversee the farm operations, including crop planning, livestock management, resource allocation, and marketing. The farm workers working outdoors face extreme weather conditions, physical exertion, and potential hazards. This farm's workforce is diverse with varying levels of income, education, and employment status.

Screening of participants was based on their willingness to take part as well as the inclusion and exclusion criteria listed below, and both male and female participants were included, and there were no exceptions.

Inclusion criteria:

- Workers who work in hot outdoor environments.
- Healthy individuals within the working age of 18-60 years.
- Workers employed at the farm can provide informed consent and are willing to participate in the study.

Exclusion criteria:

- Workers with pre-existing health conditions such as high Blood pressure, Diabetes, Asthma, long long-term medications will be excluded from the study.
- Workers unable to provide informed consent, and those unwilling to participate.

3.6 Data Collection

3.6.1: Qualitative data collection

A qualitative semi-structured interview was used in this study to collect detailed information from managerial and supervisory staff members at East Range Sd3 Farm, shown in Appendix F Considering the limited number of staff, it was decided to use a census sampling method that incorporated all six (1 manager and 5 supervisors). These interviews, lasting approximately 30-45 minutes, aimed to gather in-depth insights into the farm's occupational health and safety (OHS) practices, challenges, and strategies related to heat stress and healthcare accessibility. It also allows the exploration of subjective experiences and

perspectives, providing valuable context to the quantitative data collected in the subsequent phase of the research.

3.6.2: Quantitative data collection

Following the interviews, a quantitative survey was carried out among the remaining farm workers, comprising both permanent and non-permanent employees. A structured questionnaire was administered to a sample of farm employees, selected from a total population of 120, making it 114 in total. A stratified random sampling method was used. The population was first divided into two strata, permanent workers (n = 50) and non-permanent workers (n = 64). 30% of each stratum was selected to maintain balance and limit the scope of the study.

To ensure randomness and reduce selection bias, Microsoft Excel was used to generate random numbers. Each worker within a stratum was first assigned a unique identification number (e.g., P1 to P50 for permanent workers). Excel's =RAND () function was applied to each ID to generate a random decimal between 0 and 1. The data was then sorted in ascending order of the random numbers, and the top 15 and 19 entries were selected for the permanent and non-permanent worker groups, respectively. In this manner, 15 permanent workers and 19 non-permanent workers were selected through simple random sampling by allocating a distinct number to each and choosing randomly via a computer random number generator. This gives us a total sample size of 40 participants, both interviewed and questioned, distributed as follows: 1 Manager (census), 5 Supervisors (census), 15 Permanent Workers (random sample), 19 Non-permanent Workers (random sample). This approach was selected to make certain that all categories of employment on the farm were equally represented in the sample. The questionnaire was divided into sections to gather demographic information, occupational health and safety risks, heat

Temperature Data

Temperature and relative humidity data, preferably daily and hourly, are downloaded from sources such as NASA Power for the year 2024. Supplementary temperature data are collected from local weather stations to supplement the satellite-derived temperature data. Historical temperature data for the past 10 years are collected to identify trends and patterns in temperature variability, considering the farm was

Parameter	Description	Data source	Format
Air temperature (T)	Daily or hourly Mean, maximum, and minimum temperatures	NASA POWER	CSV
Relative humidity (RH)	Percentage of moisture content in the air	NASA POWER	CSV
Solar Radiation	Download solar radiation for direct sunlight areas	NASA POWER	CSV
Water vapor pressure (e)	Derived from temperature and relative humidity	Calculated using temperature and RH	

established in 2016.

TABLE 3.1:PARAMETERS FOR CLIMATE DATA

Healthcare Accessibility Data

Data on healthcare facilities will be gathered from government health departments and local healthcare providers, including the location of healthcare facilities, types of services offered, and accessibility in terms of travel time and distance from the farm. All healthcare facility locations will be accurately geocoded, and a transportation network will be created using GIS software, incorporating roads, paths, and other relevant routes.

Socioeconomic Data

Socioeconomic data will be collected through questionnaires and interviews with farm workers, gathering information on income levels, education, housing conditions, and employment status. The collected data will then be cleaned and validated to ensure accuracy and completeness.

3.7: Data Analysis

3.7.1: Qualitative data analysis

The qualitative data from the interviews will be analysed using thematic analysis, which involves the following steps:

1) Familiarization with Data: Reading through the transcripts several times to understand the content.
2) Coding: Identifying key themes and patterns in the data. Responses will be coded, and key topics such as OHS policies, barriers faced, and measures implemented to address heat stress and health care access within the organization will be extracted.
3) Theme Development: Organizing the codes to get insights and understand the issues shared by the participants.
4) Reviewing Themes: Test themes against the data to ensure accuracy
5) Final Analysis: Interpreting the themes with the research questions to connect findings and objectives of the study.

3.7.2: Quantitative Data Analysis

GIS software ArcGIS will be used for spatial analysis.

Temperature Variability Analysis Techniques

ArcGIS is used to prepare and georeference temperature data. To create a continuous surface of temperature data, interpolation techniques will be employed, specifically Inverse Distance Weighting (IDW). The WBGT is calculated using the Raster Calculator using the following formular:

WBGT (°C) = 0.567 × Ta + 0.393p + 3.94

The WBGT data will be used to create a heat map, delineating regions based on varying levels of heat stress.

Healthcare Accessibility Analysis

ArcGIS software was used for geocoding healthcare facilities located near East Range Sd3 Farm, obtained from government health databases. Then concentric buffers of 5KM, 10KM, and 15KM were created around healthcare facilities. These distances reflect reasonable travel expectations for rural workers, based on common accessibility benchmarks. The proportion was identified by the percentage of the workforce living within each buffer zone, indicating inequalities in access.

Occupational Health and Safety (OHS) Analysis

This section outlines the methods used to analyse data collected from the farm worker questionnaire concerning occupational health and safety (OHS). The objective was to identify common hazards, risk factors, and challenges affecting workers' health and safety on the farm. Descriptive statistics, specifically frequencies and percentages, were used to summarize key OHS-related variables. The analysis was conducted using Microsoft Excel to provide a clear overview of working conditions and health risks experienced by participants.

Socioeconomic Analysis

The structured questionnaire included socioeconomic variables such as the level of education, number of dependents in the household, and financial difficulty related to work-related injuries, and its data was analyzed through descriptive statistics. Responses were coded and numerically entered into Microsoft Excel spreadsheet. Descriptive statistics (frequencies and percentages) were employed to summarize the distribution of responses. Also, a comparative

analysis by employment status (permanent vs. non-permanent workers) was conducted to determine the differences in social class. The data was presented using tables and pie charts.

3.8: Validation and Reliability

To ensure the validity and reliability of the study, multiple data sources will be triangulated. Cross-validation techniques were applied to verify the accuracy of geospatial data. Statistical analysis will be conducted using software such as Excel. Descriptive statistics will summarize the data, while inferential statistics will test hypotheses and examine correlations between variables.

3.9 Ethical Considerations

To ensure the ethical integrity of the research, the researchers adhered to the frameworks and guidelines established by relevant research institutions and regulatory bodies. Informed Consent involves making certain that the participants have clearly understood the purpose of the research, the risks, and the benefits. Ensure transparency about how data will be used, stored, shared, and secured. Also, ensure there is confidentiality and anonymity by maintaining the privacy of the respondents, especially the farm workers, and do not reveal any personal information without permission. Also, inform the participants of their right to decline to continue participating in the research.

CHAPTER 4: RESULTS

4.1 Demographic and Employment Characteristics

The study analysed a workforce comprising both non-permanent and permanent workers, with non-permanent staff making up a significant proportion (56%). The workforce was predominantly female, accounting for approximately 65% of the respondents. The age distribution indicated a relatively young workforce, with around 21% of workers in their twenties and about 15% under 20 years old. Farm tenure varied, with roughly 29% of workers having less than a year of experience, while approximately 18% had worked for over a decade. Education levels among the workers were diverse, with secondary schooling being

the most common level attained. Regarding household responsibilities, about one-quarter of workers supported 1-2 dependents, and approximately another third supported 5-6 dependents on their income.

4.2: Themes from Manager and Supervisor Interviews

The analysis of interviews with 1 manager and 5 supervisors revealed four main themes related to occupational health and safety: lack of formal OHS policies and safety procedures, rather than relying on experience. This leads to challenges in implementing effective OHS practices and limited access to healthcare services.

Theme 1: Lack of Formal OHS Policies and Reliance on Experience

All respondents indicated that there is a lack of formal OHS policies on the farm. Safety procedures are based on traditional practices, common sense, and experience. Thus, there is more reliance on informal knowledge rather than structured guidelines. Also, there is the absence of documented policies legally backed by safety regulations, leading to inconsistent implementation and practices across the farm. According to the response quote from the Manager, "There are no formal OHS policies; we rely on experience," thus alluding to the theme. Also, Supervisor 1 agreed when they gave the response, “There are no written policies, we rely on the old safety ways. "Supervisor 3 further highlighted the informalities by noting that “It's more common-sense approaches, not formalized.

Theme 2: Informal Methods of Safety Enforcement

Supervisors and managers use verbal instructions, demonstrations, and observational advice to guarantee worker compliance even in the absence of explicit regulations. The main ways that safety procedures are communicated are orally and through on-the-job training, verbal reminders, and briefings every day, as opposed to written procedures. Practical guidance and examples as opposed to formal instruction. Reactive methods, as opposed to proactive ones, deal with problems on the ground. This adaptive approach ensures immediate problem resolution but lacks long-term strategic planning. This was concluded by the manager with statements like "Verbal instructions and on-the-job guidance." Also, from considering the supervisor's 1 response when he noted that "Remind workers daily during task assignments.

Theme 3: Challenges and Barriers to Implementing Effective OHS Practices

All supervisors and the manager mentioned significant barriers such as resource constraints, limited budget, limited awareness and training, and old equipment were cited as key challenges leading to difficulties in establishing and maintaining effective OHS practices. Workers lack structured education on OHS. Difficulties in ensuring worker compliance and a lack of overall support were also noted: "Some workers don't listen, and we have no resources."

Theme 4: Limited Access to Healthcare Services

Healthcare access remains a significant challenge due to farm location and resource constraints. Transportation challenges and the distance to healthcare facilities were major concerns. Limited transport availability prevents workers from accessing clinics. Dependence on local clinics for serious cases. Few healthcare facilities are nearby, leading to delayed treatment. Reliance on self-management unless critical cases arise, as the supervisor noted, "Very few go for care unless critical, no medical staff onsite. "Also, the manager further supported, "We refer serious cases to local clinics; transport is a challenge."

4.3: Farm worker questionnaire results

This section presents the results of the Occupational Health and Safety (OHS) and Socioeconomic analysis data collected from the farm worker questionnaire.

Workload and Task Distribution

The farm is a demanding work environment characterized by extensive daily workloads. A significant proportion of farm workers consistently engage in prolonged shifts, often exceeding standard working hours. This high prevalence of long hours, combined with the physically demanding nature of their primary tasks such as cattle herding, machinery operation, weeding, planting, and harvesting, suggests substantial physical strain and continuous exposure to outdoor elements. These conditions are particularly concerned given the often-harsh agricultural environment they work in.

TABLE 4.1:WORKLOAD AND TASK DISTRIBUTION

Indicator	Category	Frequency	Percentage (%)
Hours Worked/Day	<6 hours	11	32.35
	6–8 hours	11	32.35
	9–10 hours	9	26.47
	>10 hours	3	8.82
Tasks Performed	Cattle herding	17	24.29
	Machinery operation	15	21.43
	Weeding	15	21.43
	Planting	13	18.57
	Harvesting	10	14.29

PPE Use and Injury Reporting

Figure 4.1 shows that most farm workers used PPE inconsistently; most of them reported using it sometimes or not at all. This non-utilization of the PPE is likely to be directly associated with the alarming prevalence of work-related injuries, which was expressed by a significant fraction of participants.

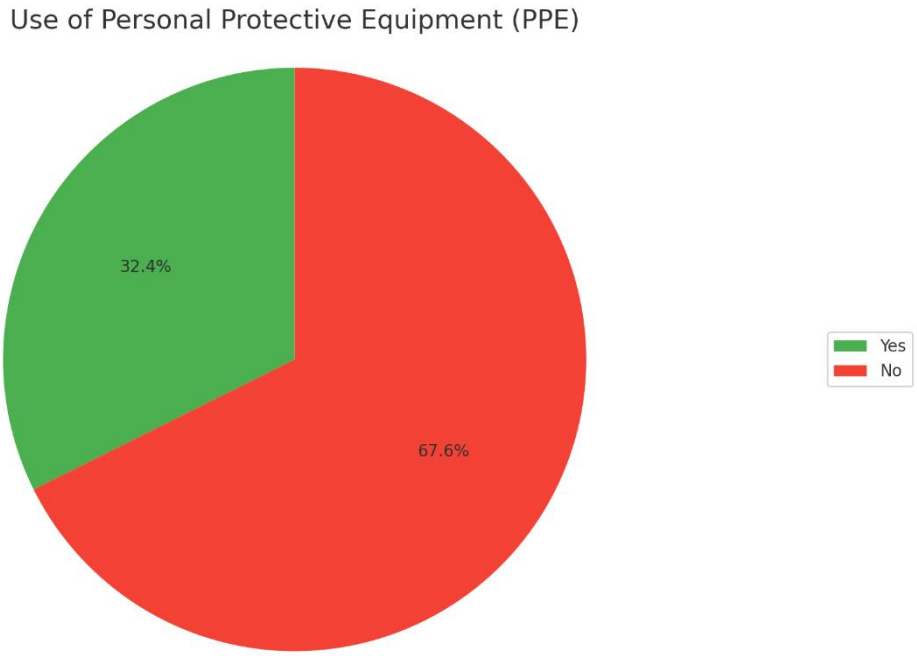


FIGURE 4.1 USE OF PPE

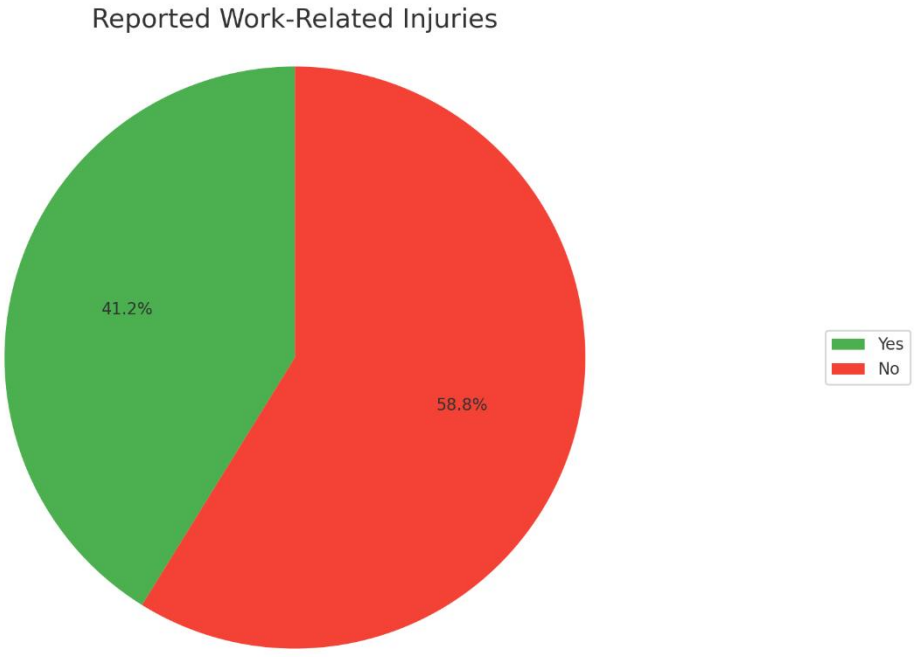


FIGURE 4.2: REPORTED WORK-RELATED INJURIES

Training responses

The analysis indicates a concerning lack of formal safety training among most farm workers, suggesting inadequate preparation and a lack of awareness before conducting a task. This training deficit likely contributes to the high prevalence of reported heat-related symptoms and injuries, with multiple symptoms affecting a notable percentage of the workforce, as shown in Figure below.

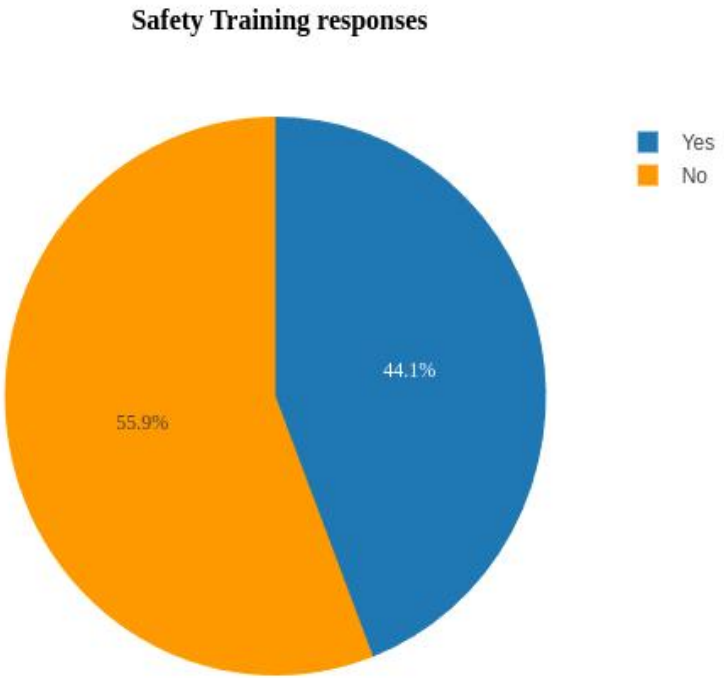


FIGURE 4.3:SAFETY TRAINING RESPONSES

Heat stress symptoms findings

A significant number of respondents reported experiencing heat-related symptoms, with fainting being the most common, accounting for10.71%. Other symptoms included dehydration, dizziness, heat rash, headaches, and nausea had 9.52% individually. Less

common symptoms included heat exhaustion, heat stroke, heat stress, muscle cramps accounting and sweating for 8.33%, 7.14%, 5.95%, 5.95%, 4.76% respectively, as shown below in Figure 4.4.

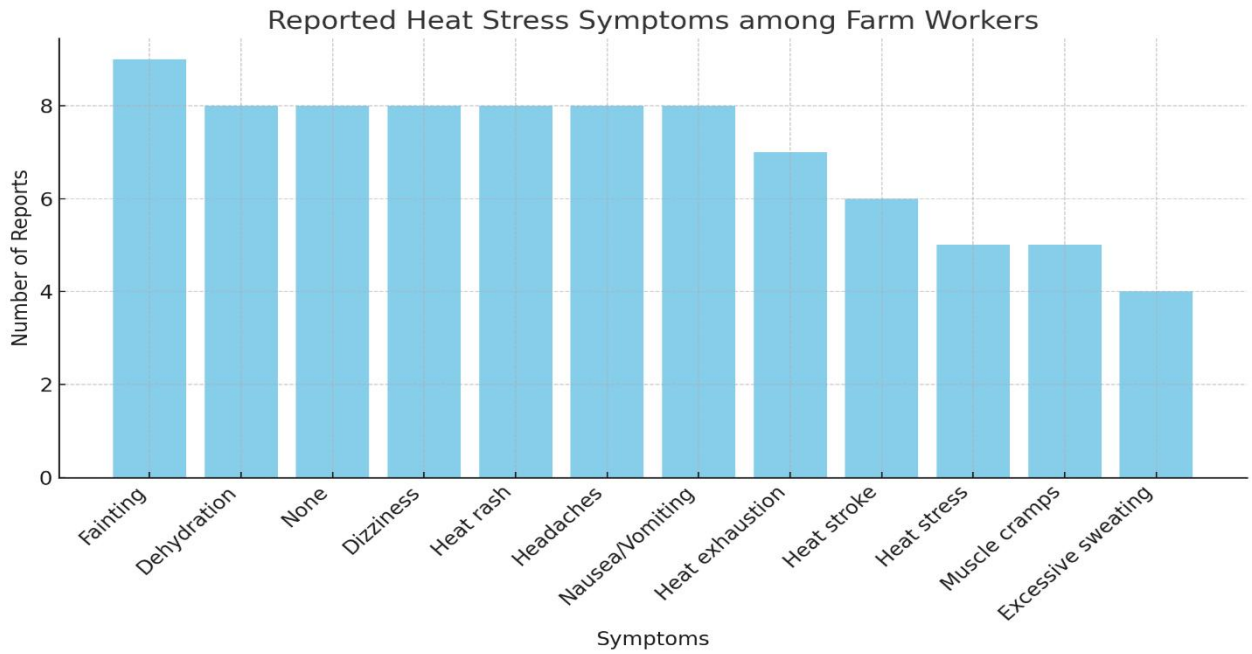


FIGURE 4.4: REPORTED HEAT STRESS SYMPTOMS

Resource access responses

Based on the responses by the farmers on the issue of access to shade and water, most workers responded having access to drinking water, but mostly relied on untreated sources (such as dams), which pose significant health risks Figure 4.5. Access to adequate shade during work hours was limited, further exacerbating the vulnerability to heat stress and underscoring a need for improved basic resource provision to safeguard worker well-being, as shown in Figure 4.6.

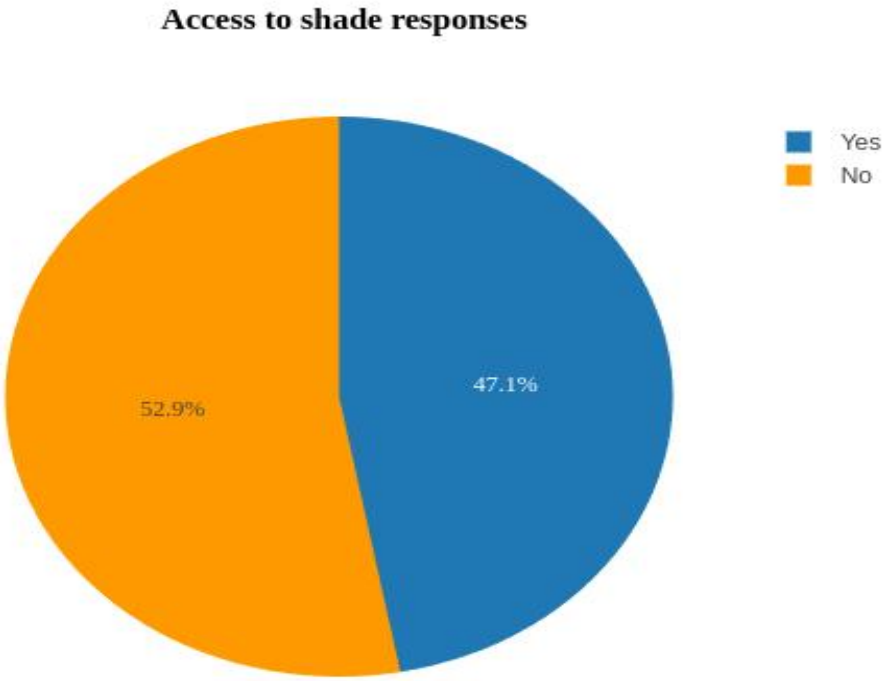


FIGURE 4.5:ACCESS TO SHADE RESPONSES

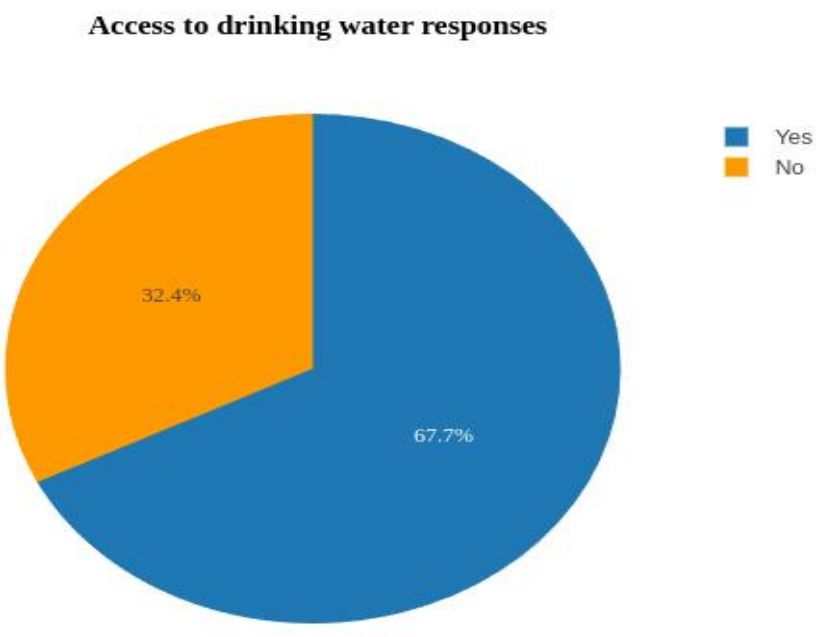


FIGURE 4.6:ACCESS TO DRINKING WATER RESPONSES

Hazard and Chemical Exposure

As shown in Appendix A, workers also cited concerns about chemical exposure, machinery, animal risks, and musculoskeletal disorders, indicating a wide range of occupational hazards beyond heat stress due to repetitive tasks and heavy lifting, and prevalent dangers associated with heavy machinery and wildlife encounters. These insights highlight the multifaceted nature of occupational hazards faced by farm workers, necessitating comprehensive safety interventions. A variety of herbicides, insecticides, and fungicides are used on the farm, some of which pose reproductive, respiratory, and dermatological risks (see Appendix B).

4.4: Socioeconomic Analysis findings

Socioeconomic disparities were evident between permanent and non-permanent workers. Non-permanent workers typically reported lower levels of education, with a higher proportion having only primary education, which reflects systemic barriers such as limited access to advanced schooling, financial constraints, or the prioritization of immediate income over education in precarious roles. In contrast, permanent workers generally showed an advantage in secondary education, likely granting them access to more stable, higher-skilled roles that often include safety training and reinforce job stability.

Furthermore, these two groups exhibited distinct financial characteristics regarding household coping strategies and vulnerability to income challenges. Permanent workers often carried greater household responsibilities, making them more susceptible to economic instability resulting from events like work-related injuries. In contrast, non-permanent workers, particularly those in part-time positions with smaller households, tended to adopt less certain financial coping strategies. This uncertainty undermines the perceived security these

strategies might offer, as they often mask the absence of formal benefits and the inherent precarities of their employment situation.

TABLE 4.2: SOCIOECONOMIC COMPARISON

Indicator	Category	Permanent Workers (N=15) (%)	Non-Permanent Workers (N=19) (%)
Education Level	No formal education	33.3	31.6
	Primary	0.2	31.6
	Secondary	46.7	36.8
Dependents	1-2	26.7	36.8
	3-4	20	26.3
	5-6	40	26.3
	>6	13.3	10.5
Financial Difficulty due to Injury	Yes	40	57.9
	No	60	42.1

4.5: Temperature Variability and Heat Stress Findings

Analysis of daily WBGT for East Range Farm during the period from 1 January to 31 December 2024 showed significant seasonal fluctuations in our environmental heat stress, highlighting possible consequences on the health and safety of farm employees. Each daily WBGT value used to estimate the occupational heat was classified into internationally agreed-upon risk categories for this purpose. The results show that over 53% of the year experienced WBGT values in the moderate to extreme range, suggesting persistent thermal stress conditions. Notably, 3.3% of days reached WBGT values above 32°C, categorized as extreme risk, warranting substantial restrictions on physical labour and mandatory preventative measures. Its interpretation is based on guidelines from ISO 7243 and the American Conference of Governmental Industrial Hygienists (ACGIH), with detailed thresholds provided in Appendix C. The detailed distribution is as follows:

TABLE 4.3: WBGT-BASED RISK CLASSIFICATION

Risk Category	WBGT Range (°C)	Days Observed	Percentage
Low	< 25.0	110	30.1%
Moderate	25.0 – 27.9	174	47.5%
High	28.0 – 29.9	44	12.0%
Very High	30.0 – 31.9	26	7.1%
Extreme	≥ 32.0	12	3.3%
Total		**366**	**100%**

The spatial variation of Wet Bulb Globe Temperature (WBGT) throughout the year also provides critical insights into occupational heat stress risk on the farm. While a comprehensive analysis of all monthly WBGT values was conducted, Figures 3 (June), 4 (December) illustrate key periods of the year, the coldest period, and the peak hot season, respectively.

During the warmest months (October to March), WBGT values peaked during the hot and humid season, with December recording the highest index values (high: 34.99°C), followed closely by January and February (highs: 34.99°C; lows:30°C). These levels far exceed the international threshold (32°C WBGT) where strenuous outdoor labour should be significantly limited or adjusted (ISO 7243). In the coolest months (June and July), the WBGT index during these months was lowest, ranging from 16.0°C to 20.0°C, indicating a markedly reduced risk of heat-related illness. In transitional months (April–May, August–September), WBGT levels were in a moderate range (20–30°C). However, September and April showed rising and falling heat stress patterns, respectively, marking the transition into and out of the hot season.

The spatial distribution of heat indicates that the northern section of the farm, which includes “Compound A,” the “Farm Offices and Warehouse,” and the “Black Water Dam,” where

most of the fields are located, exhibited higher WBGT values (red/orange), particularly during the hot season. These zones are less shaded and more open, intensifying exposure for workers stationed there. In contrast, the southern section, particularly around “Compound C,” tended to remain cooler (yellow to green on the map), suggesting reduced heat stress risks. This suggests the northern areas are generally hotter and experience greater heat stress.

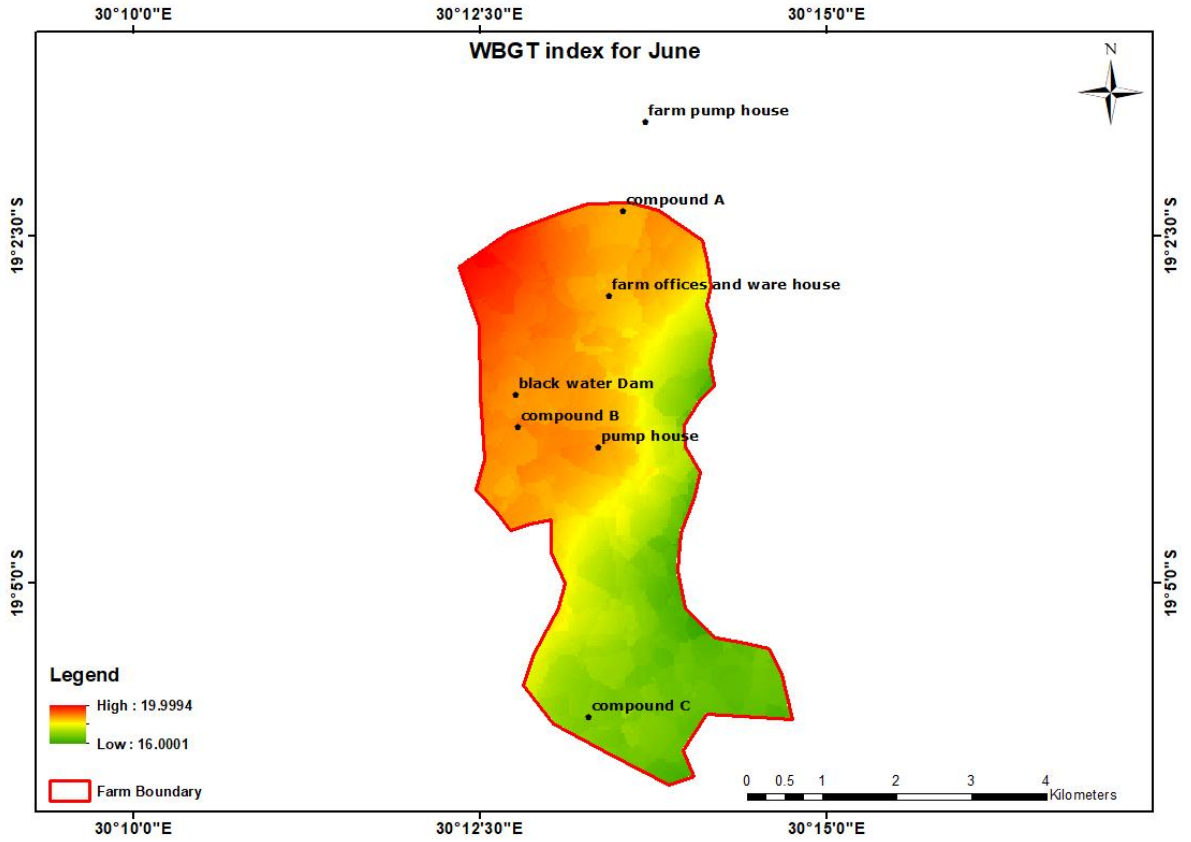


FIGURE 4.7: SPATIAL WBGT VARIATION IN JUNE

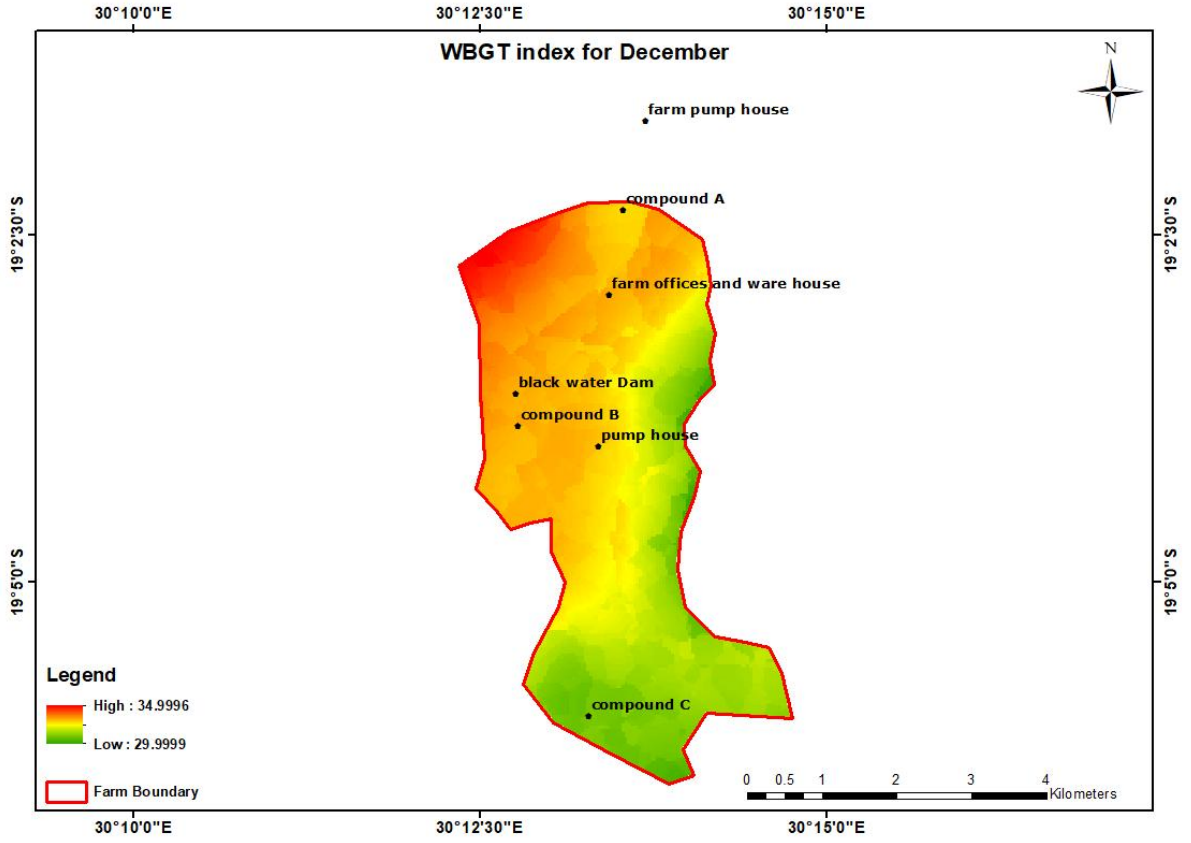


FIGURE 4.8: SPATIAL WBGT VARIATION IN DECEMBER

4.6: Healthcare accessibility findings

Figure 4 shows that approximately 53% of workers (18 out of 34) are located within the 5km buffer, indicating high accessibility and a relatively unhindered ability to reach healthcare facilities within a reasonable walking distance. The farm itself, with around 29% of the workforce (10 out of 34) residing in the 5-10km range, falls within a moderately underserved zone, suggesting transport dependence and moderate travel distances, likely requiring bicycle or vehicle transport for healthcare access. Conversely, roughly 18% of workers (6 out of 34),

primarily residing in Compound C, are located outside the 15km buffer. These residents face severe healthcare inaccessibility due to greater distances and infrastructure limitations, highlighting a critical need for policy intervention to improve service delivery and alleviate high travel burdens.

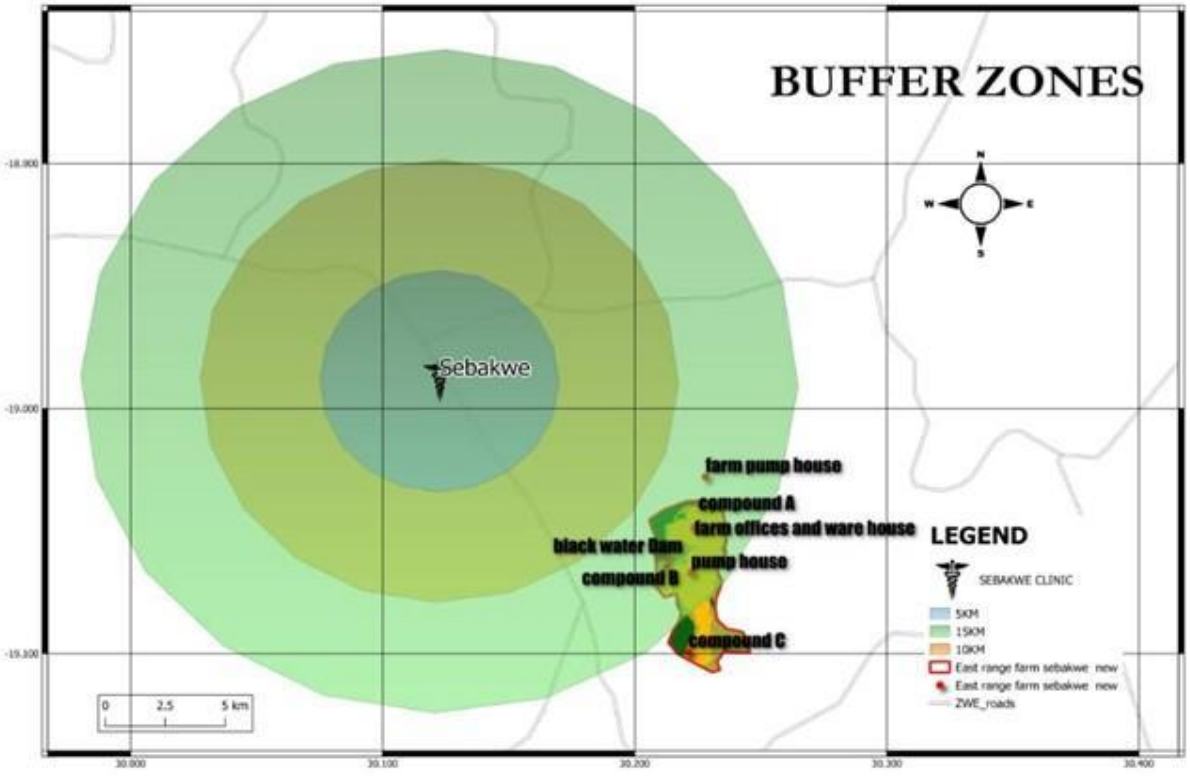


FIGURE 4.9: BUFFERING MAP

CHAPTER 5: DISCUSSION

This chapter provides a thematic discussion of results at East Range Farm, organized in relation to the four research objectives and questions. It addresses the four key occupational health and safety (OHS) elements, namely environmental hazard, socioeconomic vulnerabilities, access to healthcare services, and policy implementation gaps. The report integrates empirical evidence from the farm with relevant literature and international standards to provide a full picture of the problems faced by agricultural workers.

5.1 Occupational health and safety hazards in agriculture

The results indicate that East Range Farm operates without formal occupational health and safety (OHS) management systems. The safety practices are informal and not properly documented or clearly communicated. Hence, limited safety training, poor use of personal protective equipment (PPE). Farmworker safety information provided by employers relies heavily on on-the-job verbal safety talks, with less reliance on formal training protocols, hand-written procedures, or pre-exposure risk reduction measures. This crisis-reactive system, while dealing well with immediate threats, is incapable of building the kind of protective infrastructure needed to protect workers in the long run. Unfortunately, these trends align with the long-standing issues in agriculture mentioned by Lundqvist et al. (2017), who highlighted problems such as the lack of PPE and hazardous behavior of workers due to a lack of proper safety procedures and protocols that guide the workers.

An additional concern that exacerbates these risks is exposure to agrochemicals like atrazine and glyphosate, both hazardous to human health globally. Unfortunately, these chemicals were often treated without proper PPE or training, and the pervasive absence of standardized protocols and awareness of toxicological risks worsens workers' exposure. The physical nature of tasks such as harvesting, planting, and weeding, often carried out under pressure to achieve high daily targets (e.g., 12 bags of potatoes per worker in a day), leads to productivity being more important than the safety of workers. In addition to this, most farm workers consistently engage in prolonged shifts, often exceeding standard working hours. These longer workdays, especially in combination with high WBGT physically demanding tasks, contribute to the production of heat-related illnesses via decreased recovery periods

and greater cumulative exposure. High physical activity and poor ergonomic practices cause musculoskeletal disorders (MSDs). Tasks involving repetitive motions, awkward postures, and manual handling activities, including digging, stone picking, and potato loading, expose workers to chronic back pain and injuries. Education and training on ergonomic behaviours are almost non-existent, and this compounds these occupational hazards. These results are reminiscent of those reported for agriculture in other parts of the world, where ergonomics is largely overlooked in difficult labour-oriented tasks (Osborne et al., 2013).

5.2 Variability of Temperature and Heat Exposure

The geospatial analysis of Wet Bulb Globe Temperature (WBGT) revealed moderate to extreme heat stress, with the highest risks occurring from October through December. During this period, measured WBGT often exceeded 32°C, coinciding with peak farming activities (planting and harvesting). This implies that workers would be exposed to double risks from workload and environmental stressors in these critical periods. Furthermore, the observed symptoms of dizziness, fainting, and dehydration in workers were highly correlated with modelled reported extreme heat stress levels. This finding aligns with Simane et al. (2022), who found an association between heat exposure and diminishing returns in both productivity and health. As climate change is likely to lead to more frequent and severe heat waves, current occupational risks may compound, highlighting an urgency for intervention and adaptation. (Brimicombe et al., 2023).

5.3 Accessibility of Health Facilities and Spatial Disparities

The application of GIS analysis clearly showed marked spatial differences in the availability of healthcare to farm workers. Those living further than 10 km from health centres, particularly in "Compound C," were most vulnerable. Most depend on bicycles or walking as their main means of transport, which acts as a barrier to accessing health care when injured. In addition to this strain, there is a lack of medical facilities on site, and the fact that most of the workforce lack access to medical care and instead either treat themselves or suffer until the problem goes away. These results are consistent with broader patterns of rural health access at the national level in Zimbabwe, where health infrastructure is often inadequate and inadequately distributed (Chikanda et al., 2014). The themes from the interview reflect healthcare-related challenges such as accessing care timely and effective which leads to

workers relying on traditional and self-treatment, delaying medical care. These healthcare-related challenges demonstrate that organizational and geographical location have an impact on workers' ability to access timely and effective care, thereby making them susceptible and vulnerable to occupational hazards.

5.4 The Socioeconomic Factors and Vulnerability

The difference in social levels experienced among farm workers at East Range Farm provides new dimensions to their OHS risk stresses. A high proportion of non-permanent workers were poorly educated, had no formal contracts, no access to basic benefits such as insurance or basic training and awareness. However, permanent workers, while in a slightly better position, suffered from significant financial demands, especially for dependents, and possible loss of income when injured. These differences are indicative of wider structural injustices within Zimbabwe's agricultural labour sector. It is important to note that informal workers, by definition, are necessarily exposed to the risk generated by being removed from the protective sphere of formal labour. This reflects the conclusion of the International Labour Organization (ILO, 2016) that workers in the informal sector are consistently under-protected worldwide. These low-paid workers lack income security, job security, and formal victims' compensation coverage, which increases their vulnerability to workplace risks and severely limits their capacity to recover from injury or illness. These structural disparities impact not only individual worker welfare but also the financial stability of households and communities. Socioeconomic status remains a major determinant of the risk of occupational vulnerability for agricultural workers unless specific interventions to reduce these foundational disparities are put in place. This further supports findings by Nsiah et al., 2024 that concluded that lower education levels and poverty correlate strongly with reduced healthcare access and increased workplace injuries.

5.5 Policy Gaps and Structural Reform Required

A significant theme highlighted across this study is the everyday dependence upon informal safety practices where formal OHS has no institutional presence. Although Zimbabwe has ratified several ILO Conventions, including C129 (Labour Inspection in Agriculture), C155

(Occupational Safety and Health), and C170 (Chemicals), their implementation at the farm level is still poor. In the case of East Range Farm, there were no written safety policies, no inspection processes, and no organized training programs. The evidence shows that a gap seemed to exist between the national and the local commitment. This continued widening has been no different from the broad patterns seen across rural agricultural sectors in the Global South, where profit orientation is carried through at the expense of workers (Jakob et al., 2021). The consequences of this systemic negligence are widespread, directly affecting multiple Sustainable Development Goals (SDGs) such as SDG 3 (Good Health and Well-being), SDG 8 (Decent Work and Economic Growth), and SDG 13 (Climate Action). In the absence of basic institutional reform and a revived worker protection ethics, agricultural workers will continue to bear a disproportionate share of both environmental and structural risks.

This chapter has demonstrated the complex nature of occupational health hazards for workers at East Range Farm. These risks arise from both immediate environmental exposures (e.g., high heat, agrochemicals) as well as from broader system-wide failures such as lack of policy enforcement or poor access to care. Although unformalized safety policies allow for the flexibility of short-term responses, they are clearly inadequate for the long-term protection of workers or in terms of sustainable occupational health. The significant field will urgently need to traverse the divide between existing policy and actual practice, and for that, structural reform, higher investment in protection and training of workers, and site-specific adaptation of OHS strategies to tackle local realities of farms in rural areas are necessary.

CHAPTER 6: Conclusion and Recommendations

6.1: Summary

The aim of this study was to conduct a geospatial assessment of the occupational heat stress and healthcare accessibility faced by agricultural workers at East Range SD3 Farm, Zimbabwe. The main problem analysed was the widespread susceptibility of farm workers to multiple occupational health hazards, magnified by poor safety practices and systemic injustices. The aim of the study was to identify and understand the main occupational health and safety risk faced by agricultural workers on the East range sd3 farm in Kwekwe, focusing on the interplay between temperature variability, healthcare accessibility, socioeconomic factors and policy implementation The literature reviewed the well-established OHS problems in agriculture sector globally, especially in the developing regions, where agrochemical exposure, heat stress, musculoskeletal disorders, and the often precarious nature of the labour intensive tasks performed by farm workers which often falls outside a formal OHS framework.

In this cross-sectional study, we used a mixed-method approach by combining the use of WBGT assessment, GIS analysis, and qualitative data obtained from interviews with the farm workers to obtain a complete perspective on the life challenges and environmental exposures on the farm. The results show that farm workers who worked long hours and had no PPE, experienced high prevalence of heat-related symptoms.

WBGT evaluations revealed significant variations in temperature throughout the year, with working days frequently falling into moderate to high and extreme heat stress categories, particularly in December, a critical period associated with increased physiological health risk. Workers in open areas with poor shading were identified as being at higher. Participants working in open areas with no or little shading were more at risk. The investigation also underscored the tremendous sociodemographic differences between permanent and temporary workers, with different educational levels and serious difficulties in seeking

healthcare services. A critical finding was the absence of formal safety and health guidelines, forcing workers to rely on informal and often ineffective methods of protection.

6.2 Conclusion

In conclusion, the findings of the study at East Range Farm highlighted the urgent occupational health and safety concerns of farmworkers in Zimbabwe. The Key findings shows that excessive working hours, inadequate utilization of personal protective equipment (PPE), and high levels of heat-related symptoms are prevalent among farmworkers. The lack of formal safety policies and procedures contributes to farmers' exposure to these hazards, with farm laborers remaining exposed to preventable injury and employing informal, and in some cases substandard, there is a need for protection mechanisms and intervention that is required. The spatial analysis also revealed that healthcare accessibility is not equal, and workers in outlying areas faces challenges in accessing basic medical care. Such spatial inequalities confirm earlier intuitions that workers are exposed based on their spatial position. The study found that socioeconomic inequalities between non-permanent and permanent laborers, heighten occupational health hazards. This supports the first hypothesis that uneven employment status, education level, and access to benefits would be equivalent to uneven health outcomes, which indicates an aspect of the problem statement. Based on these conclusions to ensure that farm workers are protected the safety culture at workplaces must improve to foster safety and wellbeing. Also, multi-sectoral collaboration by governmental bodies, local communities, and international agencies must be done that invest in public awareness and strategies to improve health care issues to reduce occupational risks and improve the resilience of farm workers.

6.3: Recommendations

Based on the findings from the study at East Range Farm, three key recommendations are proposed. First, the farm should establish formal Occupational Health and Safety (OHS) policies supported by structured training programs that cover general heat stress controls, PPE usage, and emergency procedures. Also, adopt a heat stress management strategy, adjusting working hours, increased access to drinking water and shade, and provision of PPE. Establish onsite first-aid facilities, emergency transport systems, and partnerships with local clinics to support timely treatment of heat-related illnesses. Also, train few individuals of the

about first aid and emergency response. It is important to note that all these recommendations have been made considering the practicability and financial capabilities of the farm owner.

Considering the limitations of this study, future research is recommended to explore the long-term health impacts of heat exposure through longitudinal studies, particularly to identify the chronic effects for farm workers and the long-term efficacy of interventions. Expanding the geographical context beyond one farm to provide insight into the differences in farming systems and increase the transferability of findings in Zimbabwe. Research must also evaluate the effect of interventions like adjusted work routines, greater shade access, or established OHS policies on the health and safety of workers. Also, conducting a cross-comparison between farms with and without structured OHS systems can further explain the benefit of well-designed safety systems

REFERENCES

Arcury, T. A., & Quandt, S. A. (2007). Delivery of health services to migrant and seasonal farm workers. *Annual Review of Public Health, 28*, 345–363. https://doi.org/10.1146/annurev.publhealth.27.021405.102106

Bauer, J., McCoy, J. H., & Roy, P. (2020). Remote sensing applications in agriculture and environmental monitoring. *Journal of Environmental Management, 264*, 110505. https://doi.org/10.1016/j.jenvman.2020.110505

Bihin, B., De Longueville, F., & Linard, C. (2022). Estimating geographical accessibility to health services in Sub-Saharan Africa. *International Journal of Health Geographics, 21*(3), 45-61. https://doi.org/10.xxxx/xxxx

Brimicombe, C., Huber, V., & Kjellstrom, T. (2023). Wet bulb globe temperature: Indicating extreme heat risk on a global grid. PLOS Global Public Health, 3(4), e0001757. https://doi.org/10.1371/journal.pgph.0001757

Chikanda, A., Crush, J., & Tawodzera, G. (2014). Medical xenophobia and Zimbabwean migrant access to public health services in South Africa. Journal of Ethnic and Migration Studies, 40(4), 655–670. https://doi.org/10.1080/1369183X.2013.830504

Food and Agriculture Organization of the United Nations. (2001). *The role of agriculture in the development of least-developed countries and their integration into the world economy* (A/CONF.191/BP/6). Geneva: UN.

Epstein, Y., & Moran, D. S. (2006). Thermal comfort and the heat stress indices. *Industrial Health, 44*(3), 388-398. https://doi.org/10.2486/indhealth.44.388

Galvis, L. (2023). Occupational safety and health in agriculture: A bibliographic review. *Journal of Occupational Safety & Health, 15*(2), 120-134. https://doi.org/10.xxxx/xxxx

Golbabaei, F., Zakerian, S. A., Sardinia, H., & Monazzam, M. R. (2015). Evaluating heat stress using Wet-Bulb Globe Temperature (WBGT) index in outdoor workplaces. *Journal of Occupational and Environmental Hygiene, 12*(5), 378-385. https://doi.org/10.xxxx/xxxx

Hajizadeh, R., Golbabaei, F., & Monazzam, M. R. (2015). A modified WBGT index using satellite data for remote heat stress assessments. *Environmental Research, 140*(1), 78-85. https://doi.org/10.xxxx/xxxx

Hamed, A. R., Egela, M. E., Mosa, S. E., Shahata, Y. A., Allam, H. K., & Younis, F. E. (2018). Effect of heat stress on agricultural field workers safety. *Egyptian Journal of Agricultural Research*, 96(4), 1515-1530.

Hamed, M., Nouri, J., & Jafari, M. (2018). Risk assessment of heat stress on agricultural workers. International Journal of Environmental Health Engineering, 7(1), 1–7. https://doi.org/10.4103/ijehe.ijehe_7_17

International Labour Organization. (2000). *Safety and health in agriculture: Report VI (1), International Labour Conference, 88th Session, 2000*. Geneva: International Labour Office. Available at: https://www.ilo.org

International Labour Organization. (2016). Non-standard employment around the world: Understanding challenges, shaping prospects. Geneva: ILO.

International Labour Organization. (2024). *Safety and health in agriculture*. International Labour Office. Retrieved from https://www.ilo.org

Instituto Nacional para la Seguridad y Salud Ocupacional. (2022). Workplace safety in agriculture: A statistical analysis of injuries and hazards. *Occupational Safety Journal, 18*(4), 102-117.

Jakob, M. C., Santa, D., Holte, K. A., Sikkeland, I. J., Hilt, B., & Lundqvist, P. (2021). Occupational health and safety in agriculture – A brief report on organization, legislation, and support in selected European countries. Annals of Agricultural and Environmental Medicine, 28(4), 452–457. https://doi.org/10.26444/aaem/140197

Kjellstrom, T., Briggs, D., Freyberg, C., Lemke, B., Otto, M., & Hyatt, O. (2016). Heat, human performance, and climate change. *Industrial Health, 54*(5), 301–309. https://doi.org/10.2486/indhealth.2015-0123

Lemke, B., & Kjellstrom, T. (2012). Calculating heat exposure in an outdoor environment: A review of methodologies. *Global Health Action, 5*(1), 32-45. https://doi.org/10.xxxx/xxxx

Lobell, D. B., & Burke, M. (2010). Climate change and food security: The consequences of global warming on agriculture. *Science, 328*(5981), 1030-1033. https://doi.org/10.1126/science.1186828

Lundqvist, P., Jakob, M. C., & Holte, K. A. (2017). Challenges and strategies in preventing occupational injuries in agriculture: A global perspective. Journal of Agromedicine, 22(3), 217–225. https://doi.org/10.1080/1059924X.2017.1332801

Mangundu, M. (2020). Accessibility of healthcare in rural Zimbabwe: The perspective of nurses and healthcare users. *African Journal of Primary Health Care & Family Medicine*, 12(1), Article 1. https://doi.org/[DOI]

Matabanchoy-Salazar, L. (2021). Occupational accidents and diseases in the agricultural sector: A global perspective. *Journal of Agricultural Safety, 27*(3), 215-230. https://doi.org/10.xxxx/xxxx

McCarroll, J. R., Hamann, C., & Reis, A. (2018). Heat exposure and work-hour reduction among agricultural laborers. *Journal of Environmental Health, 80*(5), 47-56. https://doi.org/10.xxxx/xxxx

Méndez-Lázaro, P., Martinez, P., Rodriguez, E., Hunziker, S., & Méndez-Tejeda, R. (2018). Climate change, heat, and mortality in the tropical urban areas of Puerto Rico. *International Journal of Environmental Research and Public Health, 15*(9), 2042. https://doi.org/10.3390/ijerph15092042

Moyo, S., Ncube, C., & Phiri, T. (2017). GIS-based analysis of healthcare accessibility in rural Ghana. *African Journal of Health Studies, 29*(2), 134-150. https://doi.org/10.xxxx/xxxx

Morabito, M., Messeri, A., Crisci, A., Pratali, L., Bonafede, M., Marinaccio, A., & Baldasseroni, A. (2019). Heat warning and public health measures in agriculture. *Occupational and Environmental Medicine, 61*(6), 303-315. https://doi.org/10.xxxx/xxxx

Narváez-Chaves, M. Á., Ramirez-Castro, J. F., Romero-Ontibón, M. A., Mojica, L. V. R., Riaño-Casallas, M. I., & Palencia-Sánchez, F. (2024). Trends in occupational accidents and

the departmental competitiveness index in Colombia between 2020 and 2023. SocArXiv. https://doi.org/10.31219/osf.io/6h4dn

Neziri, H. (2022). Socioeconomic disparities in health outcomes: Evidence from the Twente region. *European Journal of Public Health, 30*(4), 542-552. https://doi.org/10.xxxx/xxxx

Nguyen, T. T., Vo, P. H., & Tran, M. D. (2018). Occupational hazards among agricultural workers: Chemical, biomechanical, and physical exposure. *International Journal of Occupational Safety and Health, 14*(2), 115-129. https://doi.org/10.xxxx/xxxx

Nsiah, K., Amoah, S. T., & Ofori-Asenso, R. (2024). Healthcare accessibility in rural sub-Saharan Africa: A spatial analysis approach. *African Journal of Health Sciences, 31*(1), 45–61. https://doi.org/10.4314/ajhs.v31i1

Osborne, A., Blake, C., Meredith, D., Kinsella, A., Phelan, J., McNamara, J., & Cunningham, C. (2013). *Work-related musculoskeletal disorders among Irish farm operators*. *American Journal of Industrial Medicine, 56*(2), 235–242. https://doi.org/10.1002/ajim.22092

Pradhan, B., Sahoo, D., & Kumar, M. (2020). Impact of heat stress on agricultural workers: A systematic review. *Environmental Research, 186*, 109552. https://doi.org/10.1016/j.envres.2020.109552

Ricketts, T. C. (2014). Geographic disparities in health outcomes: A review of concepts and methods. *Annual Review of Public Health, 35*, 45–63. https://doi.org/10.1146/annurev-publhealth-032013-182419

Sallis, J. F., Cerin, E., Conway, T. L., Adams, M. A., Frank, L. D., Pratt, M., & Owen, N. (2018). Physical activity in relation to urban environments: A global perspective. *The Lancet, 392*(10151), 398–408. https://doi.org/10.1016/S0140-6736(18)31844-1

Stoecklin-Marois, M. T., Hennessy-Burt, T., & Schenker, M. B. (2017). GIS mapping and pesticide exposure among migrant farmworkers in California: A case study. *Environmental Research, 154*, 45–52. https://doi.org/10.1016/j.envres.2017.01.014

Simane, B., Woldie, W., & Nigatu, T. (2022). Occupational heat stress in the floriculture industry of Ethiopia: Health risks and productivity losses. Journal of Environmental and Occupational Health, 61(2), 101–113.

Turner, B. L., Kasperson, R. E., Matson, P. A., McCarthy, J. J., Corell, R. W., Christensen, L., & Schiller, A. (2003). A framework for vulnerability analysis in sustainability science. *Proceedings of the National Academy of Sciences, 100*(14), 8074–8079. https://doi.org/10.1073/pnas.1231335100

UNEP. (2020). Pesticides and environmental hazards in Africa: Policy and practice gaps. United Nations Environment Programme.

Xiang, J., Bi, P., Pisaniello, D., & Hansen, A. (2014). *Health impacts of workplace heat exposure: An epidemiological review*. Industrial Health, 52(2), 91–101. https://doi.org/10.2486/indhealth.2012-0145

Zhou, Y., Guo, Y., Liu, Y., & Wu, W. (2015). *Occupational health and safety in China: Current situation, challenges, and future directions*. Environmental Health Perspectives, 123(5), 275–283. https://doi.org/10.1289/ehp.1408655

APPENDIXES

Appendix A: Hazard Concerns

Hazard Concerns	Agrochemicals	15	27%
	Heavy Machinery	12	22%
	Animals	12	22%
	Musculoskeletal disorder	16	29%

Appendix B: Agrochemicals used at the farm

Agrochemicals	Use	Potential harm
Atrazine	Herbicide for maize	Endocrine disruption, reproductive issues, potential cancer risk
Glyphosate	Herbicide for maize, potatoes	Possible links to non-Hodgkin lymphoma, endocrine disruption
Chlorfenapyr	Insecticide for potatoes	Neurotoxicity, skin, and eye irritation
Tebuconazole	Fungicide for wheat	Potential endocrine disruption, reproductive effects
Metolachlor	Herbicide for potatoes	Eye and skin irritation, potential liver effects
Halosulfuron	Herbicide for maize	Skin irritation, potential reproductive

		effects
Nicosulfuron	Herbicide for maize	Skin irritation, potential endocrine disruption

Appendix C: WBGT Risk Thresholds (ISO 7243 / NIOSH / ACGIH)

WBGT (°C)	Heat Stress Risk	Recommendation
< 25	Low	Safe for most people
25–27.9	Moderate	Monitor hydration; caution for prolonged work
28–30.9	High	Heat stress likely for moderate-heavy labour
31–32.9	Very High	Frequent rest breaks required
≥ 33	Extreme	Stop heavy work; medical supervision recommended

Appendix D: Summary of Key Occupational Hazards, Their Sources, and Associated Impacts on East Range Farm

Hazard	Source/Activity	Effects/Impact
Excessive heat	Outdoor work during peak temperatures (Oct-Dec)	Heat stress, dehydration, fainting, reduced productivity, cardiovascular strain
Agrochemical exposure	Spraying, weeding, planting without PPE	Respiratory issues, skin irritation, potential long-term toxicity (e.g., cancer)
Physical strain	Cattle herding, machinery operation, lifting loads	Musculoskeletal pain, fatigue, back injuries
Poor water quality	Use of untreated dam water	Gastrointestinal infections, dehydration-related complications
Inadequate	Lack of shelters in fields	Exacerbated heat symptoms, reduced

shade/rest		recovery time
Lack of safety training	Informal safety practices, no SOPs	Increased injury risk, poor hazard recognition
Poor healthcare access	Long distances to clinics, lack of on-site services	Untreated injuries, delayed response to emergencies
Long working hours	Economic pressure, seasonal demand	Fatigue, burnout, increased risk of mistakes/injuries
Lack of PPE	Inadequate provision, non-compliance	Chemical exposure, heat absorption, physical injury

Appendix E

FARM WORKERS QUESTIONNAIRE Questionnaire ID:

BINDURA UNIVERSITY OF SCIENCE EDUCATION

INTRODUCTION

I am Magaya Liliosa, a final year master's student in Safety, Health, and Environmental Management at Bindura University of Science Education. As part of my research, I am conducting a study titled "Geospatial Analysis of Occupational Heat Stress and Healthcare Accessibility for Agricultural Workers at East Range SD3 Farm." This questionnaire seeks to gather valuable insights into the occupational health challenges and heat-related risks faced by agricultural workers like yourself. Your participation is entirely voluntary, and all responses will be treated with utmost confidentiality. Your input will significantly contribute to the understanding and mitigation of heat stress-related issues in agricultural settings. You may withdraw at any time.

Signature of participant: _____ Date: ____/____/2025

Instruction

Please put a cross (X) against a number indicating your response for each item.

This questionnaire is for research purposes only. Your responses will remain confidential.

Section 1: Demographic Information & Employment Details

1. What is your age? ☐ Under 20 ☐ 20–29 ☐ 30–39 ☐ 40–49 ☐ 50 and above
2. Gender: ☐ Male ☐ Female
3. How many years have you worked on this farm?

☐ Less than 1 year ☐ 1–3 years ☐ 4–6 years ☐ More than 6 years

4. Education level: ☐ No formal education ☐ Primary ☐ Secondary ☐ Tertiary

5. Number of years working on this farm: ☐ <1 ☐ 1–3 ☐ 4–6 ☐ 7–10 ☐ >10

6. Type of work mostly done:

☐ Crop farming ☐ Livestock herding ☐ Operating machinery

☐ Carrying/hauling loads ☐ Spraying pesticides ☐ Other: _____

Section 2: Occupational Health and Safety

7. How many hours do you work per day?

☐ Less than 6 ☐ 6–8 ☐ 9–10 ☐ More than 10

8. What tasks do you perform on the farm? (Tick all that apply)

☐ Planting ☐ Weeding ☐ Harvesting ☐ Cattle herding ☐ Machinery operation

☐ Other: _____

9. Peak working months (e.g., harvest, ploughing): _____

10. Do you use any protective equipment while working?

☐ Yes ☐ No. If yes, what kind? _____

11. Have you ever been injured while working on the farm?

☐ Yes ☐ No. If yes, please describe: _____

12. Do you receive training on farm safety and emergency procedures?

☐ Yes ☐ No

Section 3: Heat Stress and Health (Past 10 Years and Recent 3 Years)

13. Have you experienced any of the following? (Tick all that apply)

☐ Heat stress ☐ Heat stroke ☐ Heat exhaustion ☐ Heat rash ☐ Fainting

☐ Dizziness ☐ Excessive sweating ☐ Muscle cramps ☐ Dizziness ☐ Headaches

☐ Nausea/Vomiting ☐ Dehydration ☐ None

14. In the past 3 years, have these conditions increased in frequency or severity?

☐ Yes ☐ No ☐ Not sure

15. Do you have access to drinking water during work hours?

☐ Yes ☐ No ☐ Sometimes

16. Do you have access to shaded rest areas while working?

☐ Yes ☐ No

If yes: How often do you rest in the shade during hot days?

☐ Regularly ☐ Sometimes ☐ Rarely ☐ Never

17. Are there any hazards on the farm that concern you? (Tick all that apply)

☐ Heavy machinery ☐ Chemicals/pesticides ☐ Animals ☐ Other:

18. Do you work outdoors during high temperatures (e.g., 11 am–3 pm)? ☐ Yes ☐ No

Section 4: Safety & Health Support

Do you use any protective equipment (e.g., gloves, boots, sun hats)? ☐ Yes ☐ No ☐ Not always

19. What injuries or illnesses have you experienced at work?

☐ Cuts/wounds ☐ Sprains ☐ Respiratory problems ☐ Skin irritation ☐ Eye problems ☐ Other: _____ ☐ None

20. Was medical help easily accessible when the injury/illness occurred?

☐ Yes ☐ No ☐ Delayed

Section 5: Accessibility to Healthcare Services

21. How far is the nearest hospital or clinic from your home?

☐ Less than 5 km ☐ 5–10 km ☐ 11–20 km ☐ More than 20 km

22. Main mode of travel to clinic: ☐ Walking ☐ Bicycle ☐ Farm transport ☐ Other: _____

23. Have you ever failed to seek medical help due to: ☐ Long distance ☐ No transport ☐ Cost ☐ Clinic closed ☐ No time off work ☐ Other: _____

Section 6: Socioeconomic Aspects

24. How many people depend on your income?

☐ 1–2 ☐ 3–4 ☐ 5–6 ☐ More than 6

25. Have work-related health problems affected your income (missed workdays, medical costs)?

☐ Yes ☐ No

26. Would you be interested in a health education or support program at the farm?

☐ Yes ☐ No ☐ Maybe

END OF QUESTIONNAIRE

THANK YOU FOR YOUR PARTICIPATION

Appendix F

INTERVIEW GUIDE FOR MANAGERS AND SUPERVISORS

Introduction

The purpose of this interview is to gather information on the farm's occupational health and safety policies, the challenges you face in implementing them, and what is being done to address heat-related illnesses and healthcare access for workers. Your insights will help in research aimed at improving worker safety and health. This study seeks to assess the occupational health and heat-related challenges faced by permanent workers at this farm. Participation is voluntary, and your responses will be treated with strict confidentiality. You may withdraw at any time.

Signature of participant: _____ Date: ____/____/2025

Participant Information

Name: _____

Position: _____

Date of Interview: _____

Interviewer: _____

Section 1: Demographic Information

- How long have you worked at East Range SD3 Farm?
- What are your main responsibilities?

Section 2: Farm Policies and Practices

- What are the farm's policies and practices related to occupational health and safety?

- How do you ensure that workers are aware of and comply with these policies and practices?

Challenges and barriers:

- What are the main challenges and barriers to implementing effective occupational health and safety practices at East range sd3 farm?
- How do you address these challenges and barriers?

SECTION 3. Heat stress and healthcare accessibility

- What measures do you take to prevent heat stress at East range sd3 farm?
- How do you ensure that workers have access to healthcare services when needed?

"Thank you for your time and for sharing your experiences and insights."

"If you have any questions or further information you'd like to share, please feel free to contact me."

Notes

THANK YOU FOR YOUR PARTICIPATION