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Impact of climate change on informal street vendors: A systematic review to help South Africa and other nations (2015–2024)

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Review

Impact of Climate Change on Informal Street Vendors: A Systematic Review to Help South Africa and Other Nations (2015–2024)

Maasago Mercy Sepadi 

Department of Environmental Health, Faculty of Sciences, Pretoria Campus, Tshwane University of Technology, Pretoria 0183, South Africa; sepadimm@tut.ac.za; Tel.: +27-12-382-5196

Abstract: Climate change poses significant challenges to informal street vendors, particularly in urban settings where they operate in vulnerable environments. These challenges include economic instability, health risks, and sociopolitical exclusion, which are further exacerbated by extreme weather events and inadequate policy support. This review focuses on understanding these impacts by synthesizing lessons and exploring potential solutions from South Africa and other regions that could be implemented by governments and street vendors. A systematic review was conducted, following PRISMA guidelines, to synthesize findings from 48 studies published between 2015 and 2024. This review employed qualitative and quantitative analysis using thematic coding in ATLAS.ti and Microsoft Excel version 2024. Comparative analyses across regions and time periods were conducted to identify differences in impacts and adaptation strategies. Among the 48 studies, 52% were conducted in Africa and 50% in Asia, making these the most frequently represented regions in research on climate change and informal street vendors. Most of the publications were between 2021 and 2024 (52%). This review further highlights that climate change has led to significant economic losses, reduced working hours, and increased operational costs for informal vendors. Health impacts, such as respiratory illnesses and heat stress, are prevalent, particularly among vendors exposed to air pollution and extreme temperatures. Gender-specific vulnerabilities were noted, with women facing compounded challenges due to caregiving responsibilities and inadequate access to sanitation facilities. While Asian vendors have adopted technological solutions like mobile payment systems and cooling devices, these may not be currently feasible for South African vendors. Instead, tailored interventions that consider the local context and available resources are necessary to effectively support South African street vendors. Key recommendations include integrating vendors into urban resilience planning such as encouraging the use of cleaner and more sustainable transportation, improving access to healthcare, and providing financial support. Additionally, governments and communities should pilot the solutions identified in this review and publish their findings to inform future policies and practices.

Keywords: climate change; informal street vendors; informal sector; adaptation strategies; urban resilience; South Africa



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1. Introduction

Climate change is an urgent global issue with far-reaching impacts on various sectors, including the informal economy. Informal street vendors, who constitute a significant portion of the urban workforce in many developing countries, are particularly vulnerable to the adverse effects of climate change [1–4]. These vendors often operate in open environments, making them susceptible to extreme weather conditions, air pollution, and other environmental hazards.

Informal street vendors play a crucial role in the urban economy, particularly in developing countries where they constitute a significant portion of the workforce [5–7]. These vendors provide essential goods and services to urban populations, often at lower prices and with greater accessibility than formal retail outlets. Informal street vendors are integral to South Africa’s urban economy, providing accessible and affordable goods and services to a wide range of urban populations. They significantly contribute to local economic activity, create self-employment opportunities, and serve as a vital support system for low-income communities. Despite their economic and social contributions, these vendors often operate in hazardous environments with limited infrastructure, exacerbating their vulnerability to climate change impacts [5–7]. Climate change exacerbates existing vulnerabilities by increasing the frequency and intensity of extreme weather events, such as heatwaves, floods, and storms, which directly impact the livelihoods of street vendors. For instance, extreme heat can reduce working hours and productivity, while flooding can damage goods and infrastructure, leading to significant economic losses [1–7].

Several systematic analyses or other forms of reviews have explored the impacts of climate change on informal workers, providing valuable insights into their vulnerabilities and adaptation strategies. For instance, the Informal Economy Monitoring Study (IEMS) conducted by WIEGO examined the realities faced by informal workers, including street vendors, in cities across Africa, Asia, and Latin America [7]. This study highlighted the significant challenges posed by climate change, such as extreme heat, flooding, and air pollution, and emphasized the need for targeted interventions to support these workers. Similarly, a study by the International Institute for Environment and Development (IIED) focused on the climate-related risks faced by informal workers in Indore, India, and Harare, Zimbabwe, revealing the complex health issues linked to inadequate water, sanitation, and hygiene [4]. These studies underscore the importance of systematic reviews in identifying reliable and relevant solutions to mitigate the impacts of climate change on informal street vendors.

Surveys conducted in places such as Harare, Zimbabwe, and India have shown that heat extremes significantly reduce working times and incomes for these workers [1,4–6]. Additionally, air pollution, another consequence of climate change, poses severe health risks to vendors who spend long hours outdoors [4–10]. These conditions disproportionately affect informal street vendors, who often operate in unregulated environments without access to basic infrastructure [9,10]. Studies in South African rural areas and cities such as Johannesburg, Durban, and Cape Town have highlighted the respiratory health risks faced by informal food vendors exposed to biomass fuel and outdoor air pollution [9–16]. Similarly, street vendors in other African countries have been found to experience the same exposure [17–22]. These results are supported by studies in Asia, especially in cities like Iligan in the Philippines, which are highly aware of the harmful effects of traffic-related air pollution on their health [23–28]. The ecological challenges faced by street vendors, including air pollution, intense weather, and ergonomic hazards, further exacerbate their vulnerability [8–34]. These compounded challenges highlight the urgent need to understand and address the impacts of climate change on this vulnerable group.

Given the significant risks posed by climate change and air pollution, it is crucial to understand how informal street vendors are affected and what adaptation strategies this industry and governments can employ. Despite the critical role of informal street vendors in urban economies, there is a paucity of comprehensive studies examining the specific impacts of climate change on their livelihoods. The existing literature often focuses on broader categories of informal workers or specific aspects such as health impacts or economic losses without providing a holistic view of the intersecting challenges faced by street vendors. Moreover, there is limited research on the adaptation strategies employed by these vendors and the effectiveness of such measures in different regional contexts.

This study aligns with several United Nations Sustainable Development Goals (SDGs), particularly SDG 1 (No Poverty), SDG 3 (Good Health and Well-being), SDG 5 (Gender Equality), SDG 8 (Decent Work and Economic Growth), and SDG 13 (Climate Action) [35]. By focusing on the economic, health, and social vulnerabilities of informal street vendors, this research underscores the necessity for inclusive policies that support their livelihoods and well-being. Addressing the challenges posed by climate change to informal vendors contributes to poverty alleviation and economic growth while also promoting gender equality by highlighting the specific vulnerabilities faced by women vendors. Additionally, the study's emphasis on adaptation strategies and resilience-building aligns with global efforts to combat climate change, reinforcing the importance of integrating informal workers into urban resilience frameworks.

This study addresses a critical gap in the literature by systematically reviewing the impacts of climate change on informal street vendors and drawing lessons from South Africa and other developing economies. The review does not only examine the negative impacts but also highlights solutions for vendors and governments to improve quality of life and to support resilience for street vendors facing climate change.

Research Questions:

1. How did climate change affect the livelihoods of informal street vendors in South Africa from 2015 to 2024?
2. What are the key challenges faced by informal street vendors in South Africa due to climate change?
3. What adaptation strategies have informal street vendors in South Africa employed to cope with climate change impacts?
4. How do the impacts of climate change on informal street vendors in South Africa compare with those in other regions?

2. Materials and Methods

2.1. Study Design

This systematic review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure a comprehensive and transparent review process [36].

2.2. Search Strategy

To ensure a comprehensive and systematic review, an extensive search of relevant studies using multiple databases was conducted. The searched databases included Web of Science, Scopus, PubMed, Google Scholar, JSTOR, and ScienceDirect. The search was limited to studies published between 2015 and 2024 to capture the most recent and relevant research. As per Table 1, a combination of general and specific keywords was used, as well as Boolean operators, to refine our search. The general keywords included "Climate Change", "Informal Economy", "Street Vendors", "Urban Informal Sector", "Climate Adaptation", and "Climate Resilience". Specific keywords were tailored to capture studies focusing on the impact of climate change on informal street vendors, such as "Impact of Climate Change on Informal Workers", "Climate Change and Street Vendors", and "Vulnerability of Street Vendors to Climate Change". Regional keywords included terms like "Climate Change Impact in South Africa" and "Urban Informal Sector in Developing Countries".

Table 1. Keywords and Boolean Operators.

General Keywords	Specific Keywords	Regional Keywords	Combining Keywords
Climate Change	Impact of Climate Change on Informal Workers	Climate Change Impact in South Africa	“Climate Change” and “Street Vendors” and “Adaptation Strategies”
Informal Economy	Climate Change and Street Vendors	Urban Informal Sector in South Africa	“Informal Economy” and “Climate Resilience” and “Urban”
Street Vendors	Informal Sector and Climate Adaptation	Street Vendors in South Africa	“Heat Stress” and “Informal Workers” and “2015–2024”
Urban Informal Sector	Vulnerability of Street Vendors to Climate Change	Climate Change Impact in Developing Countries	
Informal Markets	Climate Change Adaptation Strategies for Informal Workers	Urban Informal Sector Developing Countries	
Climate Adaptation	Climate Resilience in Urban Informal Economy	Street Vendors in Developing Countries	
Climate Resilience	Extreme Weather Events and Informal Sector		
	Heat Stress and Informal Workers		
	Flooding and Street Vendors		
	Climate Change Policy and Informal Economy		

2.3. Inclusion and Exclusion Criteria

The search was limited to studies published between 2015 and 2024 to capture the most recent and relevant research. The inclusion criteria for this review were studies that focused on the impact and adaptation strategies of climate change amongst informal street vendors, were peer-reviewed, and were available in English language and in full text. The exclusion criteria included studies unrelated to climate change or informal street vendors, non-peer-reviewed articles, studies published before 2015, and reports or conference papers. Out of 48 reviewed publications, 12 focused on South Africa, representing 25% of the dataset. This proportion provides substantial insights into region-specific challenges and solutions.

2.4. Study Selection

The PRISMA flowchart illustrates the systematic process undertaken to identify and select studies for inclusion in the review (Figure A1). During the identification phase, a total of 1022 records were retrieved from various databases. No additional records were sourced from registers. As part of the initial filtering, 549 duplicate records were removed, and automation tools excluded 11 records due to ineligibility. No records were excluded for other reasons, leaving 473 records to proceed to the screening phase.

In the screening phase, the titles and abstracts of the remaining 473 records were reviewed for relevance to the study’s inclusion criteria. During this stage, 44 records were excluded as they did not meet the necessary criteria. From the remaining records, 50 reports were identified as potentially relevant and retrieved for a more detailed assessment. Importantly, all reports were successfully retrieved, with no losses during this stage.

The eligibility phase involved a thorough full-text review of the 50 retrieved reports to ensure they met the inclusion criteria. Of these, 2 reports were excluded due to not aligning with the study's scope or predefined inclusion criteria. As a result, 48 studies were deemed eligible for inclusion in the systematic review.

In the final inclusion phase, 48 studies were included in the review. These studies represent a rigorous and focused selection process aimed at ensuring that only high-quality, relevant research was analyzed. This systematic approach underscores the reliability and thoroughness of the review methodology, ensuring that the findings were based on the most appropriate and well-documented evidence.

2.5. Quality Assessment

The quality of the included studies was assessed using the Critical Appraisal Skills Programme (CASP) Systematic Review Checklist, which ensured the reliability and validity of the findings [37]. This checklist provided a structured approach to evaluate the methodological rigor, relevance, and contribution of each study to the review. The CASP checklist includes criteria such as the clarity of the research question, appropriateness of the study design, rigor of the data collection and analysis methods, and the validity of the findings. Each study was scored based on these criteria, and only those that met a minimum quality threshold were included in the final review. This quality assessment process ensured that the findings of the systematic review were based on high-quality and well-documented evidence.

2.6. Data Extraction

Relevant data were extracted from selected studies using a standardized data extraction form. The form included fields such as author, year, study design, location, sample size, key findings, climate change impacts, challenges, adaptation strategies, and regional differences.

2.7. Data Analysis

The systematic review's analysis followed a mixed-method approach. The variables for the results analysis included demographic variables, e.g., location, and climate change impacts and challenges, e.g., economic losses and health issues. In addition to conducting comparative analyses, this review emphasizes the exploration of region-specific adaptation strategies and their potential for global applicability. By identifying innovative practices from South Africa and other regions, the analysis sought to extract solutions that transcend local contexts.

2.7.1. Qualitative Analysis

The qualitative analysis employed ATLAS.ti software version 2024 for content analysis to quantify key themes related to climate change and informal street vendors, with code frequencies used to identify the most discussed concepts [38]. Comparative analysis was used to systematically explore regional differences and similarities, focusing on South Africa compared with other regions and contextualizing findings based on socioeconomic, environmental, and policy disparities. Finally, a gap analysis identified limitations and underexplored areas in the literature, providing insights for future research directions. Canvas version 2024 was used to visualize the impact of climate change on informal vendors [39].

2.7.2. Quantitative Analysis

Microsoft Excel software was used to quantitatively synthesize the data, and frequency graphs were used to provide a comprehensive quantitative synthesis of the literature,

offering valuable insights into the impacts of climate change on informal street vendors [40]. A longitudinal analysis was used to examine the evolution of research on climate change's impact on vendors over time, highlighting shifts in focus and findings.

3. Results

3.1. Study Characteristics

The 48 included studies encompassed a diverse range of geographical locations, methodologies, and focal areas, providing a comprehensive understanding of the impacts of climate change on informal street vendors (Table S1). This synthesis of study characteristics highlights the multifaceted impacts of climate change on informal street vendors and underscores the need for targeted interventions and future research to address gaps in the literature. The key characteristics of these studies included geographical distribution, study design, and sample size.

3.1.1. Study Designs and Methods

The study designs in Table S1 show that the methodologies used across the studies included qualitative (e.g., ethnographic studies and focus groups), quantitative (e.g., surveys and cross-sectional studies), mixed method, and systematic reviews. Mixed methods and qualitative studies were prevalent, offering in-depth insights into socioeconomic and health impacts. The sample sizes varied widely, from small ethnographic studies with fewer than 50 participants to larger cross-sectional surveys involving hundreds of vendors. However, some limitations, such as small sample sizes and regional concentrations, were noted. This diversity allows for an understanding of both individual experiences and broader trends.

3.1.2. Geographical Distribution of Studies

The geographical distribution showed that the studies spanned multiple regions. Figure 1 and Table S1 show the analysis highlights the geographical diversity of the studies included in the systematic review, including Africa, Asia, and America. Africa (52%) and Asia (50%) were the most frequently studied regions. South Africa (23%) and India (19%) accounted for a significant proportion of studies, emphasizing the regional focus on climate-related vulnerabilities in informal economies. They were followed by Zimbabwe (17%), then Malaysia and Thailand (both at 13%), and then Colombia, Bangladesh, and Ghana (9%).

3.1.3. Growth in the Number of Studies (2015–2024)

The graph in Figure 2 illustrates the growth in the number of studies on informal street vendors and climate change from 2015 to 2024. The overall trend shows a steady increase in research activity, highlighting the growing academic and policy interest in understanding and mitigating the impacts of climate change on vulnerable populations like informal street vendors. Out of the 48 studies, the distribution is as follows: 2015 (1 study), 2016 (8 studies), 2017 (1 study), 2018 (5 studies), 2019 (5 studies), 2020 (3 studies), 2021 (4 studies), 2022 (4 studies), 2023 (12 studies), and 2024 (5 studies).

This shows a clear upward trend in the number of studies conducted on this topic over the past decade. There was initial slow growth between 2015 and 2017 during which research activity was limited, with only 10 studies (21%) published in total. This period reflects the early stages of academic interest in the impact of climate change on informal street vendors.

Following this, there was a gradual increase between 2018 and 2020, with 13 studies (27%) published across three years. This steady growth indicates an increasing recognition of the importance of this research area and its relevance to global and local climate change adaptation strategies.

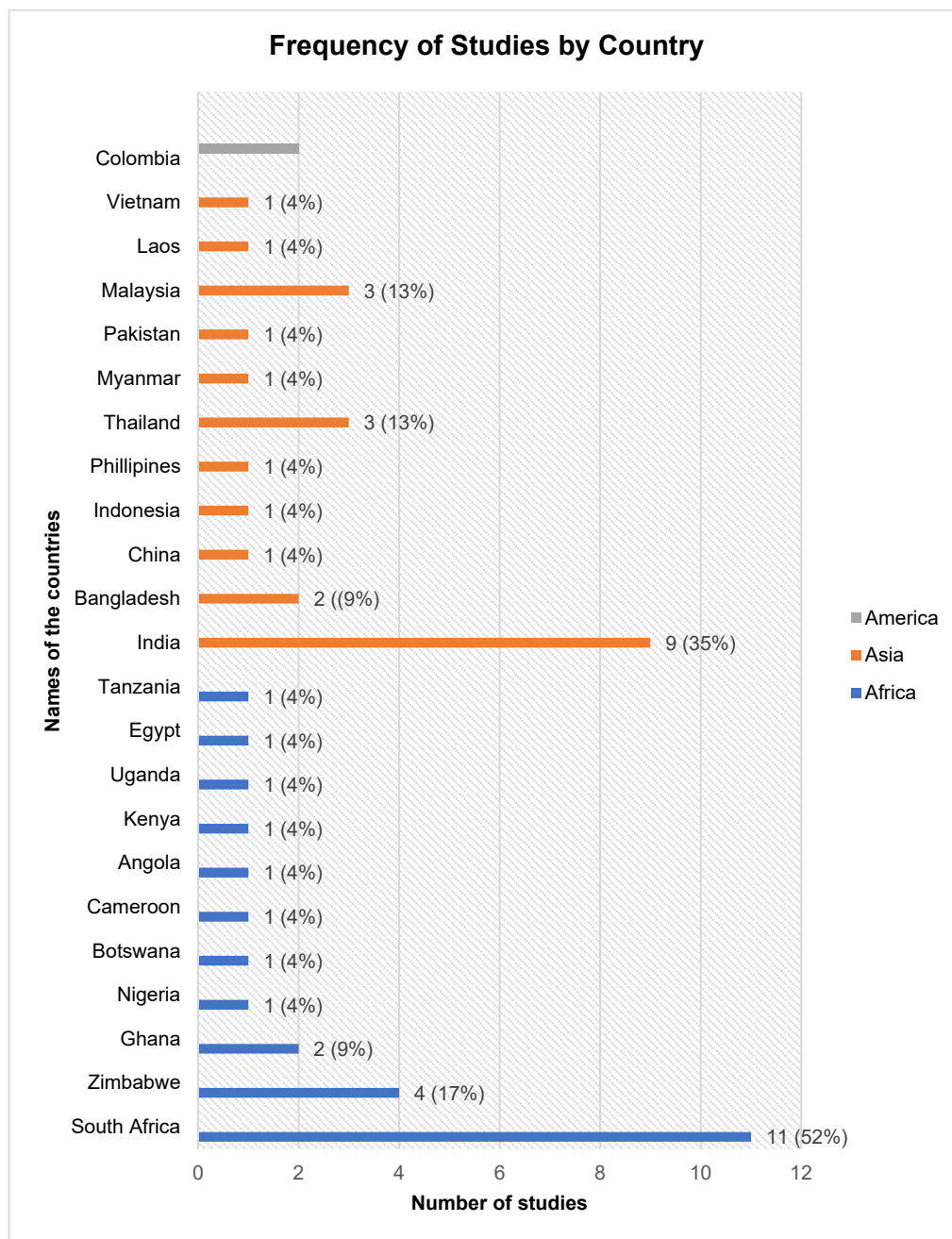


Figure 1. Frequency of studies by country.

A notable increase in publications occurred in 2023, with 12 studies (25%) published in that year alone, while the other years, including 2021, 2022 and 2024 each contributed 4 to 5 studies. The year 2023 marked the peak of research activity, reflecting a surge in interest and investment in understanding and addressing the challenges faced by informal street vendors. Despite 2024 still being in progress, 4 studies (8%) had already been published, indicating sustained interest in this field.

The sharp rise in research activity between 2020 and 2023 suggests a heightened awareness and urgency to address the challenges faced by informal street vendors due to climate change, and among policymakers, researchers, and funding bodies about the vulnerabilities of this population. This growth in research further underscores the need to develop effective adaptation strategies and inclusive policies to support informal street vendors. Continued research will be critical in addressing the evolving challenges and vulnerabilities faced by this population in the face of a changing climate.

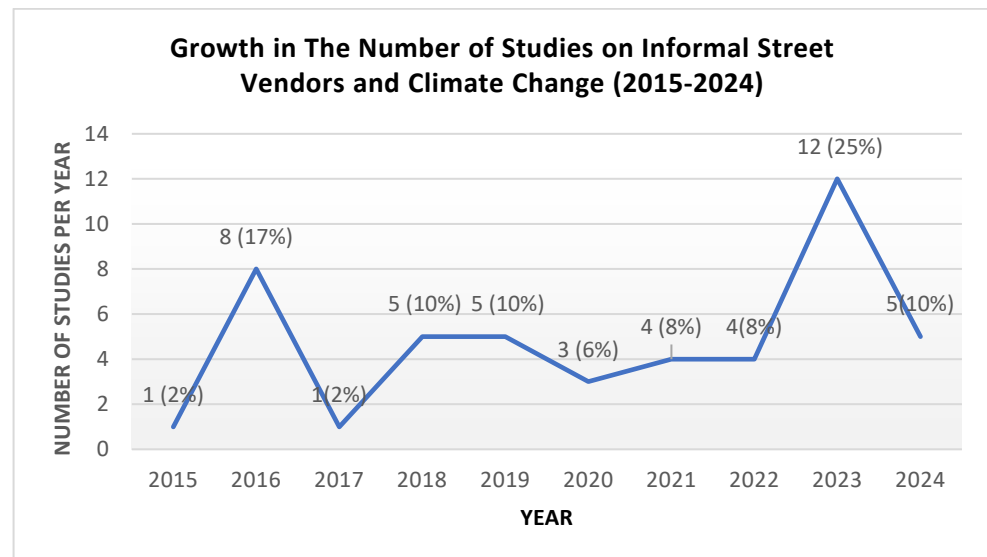


Figure 2. Growth in the number of studies on informal street vendors and climate change (2015–2024).

3.2. Common Themes and Patterns from the Studies

The bar chart in Figure 3 represents the frequency of various themes generated from the keywords used in the systematic review on climate change and informal street vendors. Street vendors emerged as the most frequently addressed theme ($n = 786$), underscoring their significance within this research, while climate change was the next most prominent theme ($n = 626$), reflecting the primary focus of this systematic review. Moderate-frequency themes included informal economy ($n = 260$), informal workers ($n = 7$), and urban informal sector ($n = 6$). These themes highlight the importance of understanding informal economic activities, a critical aspect of the study's context, indicating its centrality to the study's focus on informal street vendors and their relationship to urban settings. Low-frequency themes included informal workers, heat stress, climate resilience, climate change policy, extreme weather events, and flooding, which had significantly fewer appearances. These represent specific subtopics or less commonly discussed aspects within the overall research which accounted for less than five counts each. The chart demonstrates that the study's primary focus is on climate change and the urban informal sector, particularly the experiences of street vendors. Lower-frequency themes like "Heat Stress" and "Flooding" highlight more specific impacts or adaptation measures related to climate change. The themes with higher frequencies (street vendors, climate change, informal economy, urban informal sector, and informal workers) suggest broader and more established areas of research. The lower-frequency themes may indicate emerging areas of interest or underexplored topics in the context of informal street vendors and climate change. This further suggests an opportunity for further exploration in these areas to fill knowledge gaps.

The distribution of studies by theme and geographical focus, as shown in Table 2, shows the theme of health impacts appearing numerous times ($n = 38$) in the studies. Furthermore, it indicates a strong emphasis on health impacts in South Africa. Furthermore, other African countries have had fewer studies compared with South Africa, with a focus on economic impacts and adaptation strategies. Other developing countries significantly contribute to economic impacts and health-related research, reflecting broader urban and environmental challenges.

The word cloud analysis highlighted the intersection of informal street vending, climate change, urbanization, public health, and socioeconomic challenges, reflecting a multifaceted research focus on enhancing the resilience and well-being of informal vendors in rapidly changing environments. Dominant themes such as "Informal", "Vendors", "Street", "Health", "Climate", and "Urban" underscored the focus on health impacts, climate change, and urban challenges,

while the prominence of “Food” indicated significant attention to food safety and vending practices in informal urban settings. Secondary themes, including “Workers”, “Change”, “Economy”, “Public”, “Water”, “Air”, and “Heat”, reflected concerns about economic implications, climate-related challenges like heat stress and air quality, and public health considerations. Specific issues such as “Women” and “Gender” highlighted gender-specific challenges in informal vending, while terms like “Policy”, “Government”, and “Management” pointed to governance and regulatory challenges. Other terms such as “Heat”, “Risks”, “Respiratory”, and “Safety” emphasized health risks linked to climate change and pollution. The research scope was reflected in words like “Research”, “Study”, “Data”, and “Impact”, indicating the academic and investigative nature of the studies, while terms such as “South”, “Africa”, “India”, and “Global” suggested a geographical focus spanning regional and global contexts. General observations, including “Development”, “Income”, “Access”, and “Market”, highlighted the socioeconomic dimensions of informal vending, and mentions of “Education”, “Teachers”, and “Students” suggested connections to awareness campaigns and capacity building.

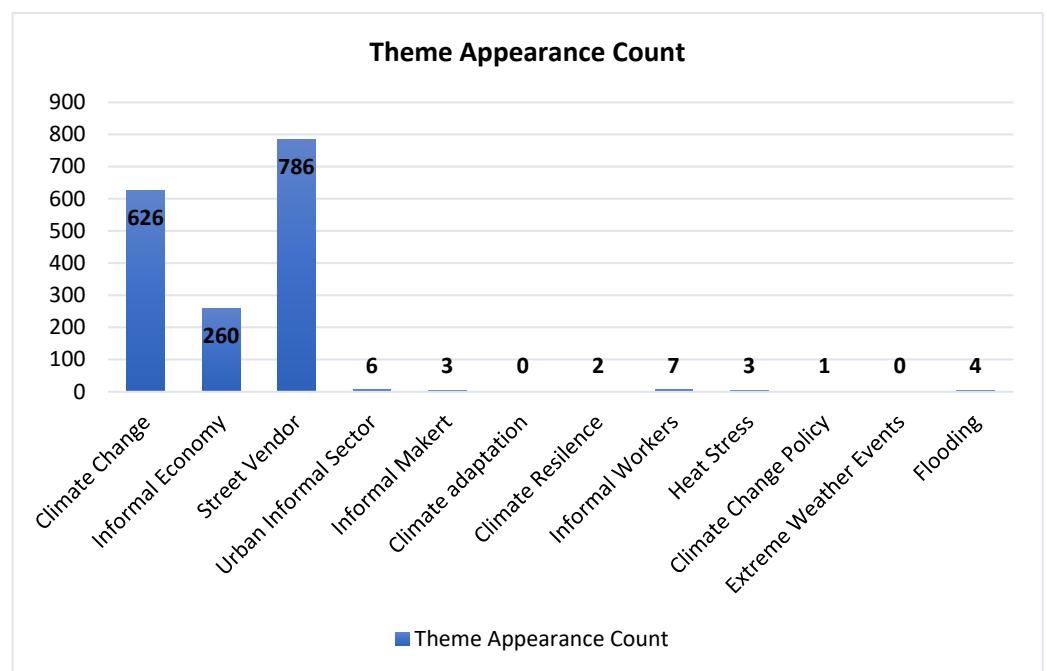


Figure 3. Theme Appearance Count.

Table 2. Distribution of research themes and geographical focus.

Theme	South Africa	Other African Countries (Excluding South Africa)	Other Developing Countries	Total
Economic Impacts	12	6	14	32
Health Impacts	18	5	15	38
Adaptation Strategies	15	7	12	34
Policy and Regulation	10	4	8	22
Gender-Specific Issues	9	3	7	19
Total	64	25	56	145

3.3. Negative Impacts of Climate Change on Informal Street Vendors

The key themes identified included economic impacts, health impacts, adaptation strategies, gender-specific vulnerabilities, and policy and regulatory challenges. Common challenges faced by vendors included regulatory exclusion, a lack of infrastructure, inadequate access to basic services, and occupational hazards. The studies predominantly

focused on health impacts and economic challenges. Other climate-related impacts included food insecurity, urban flooding, and water scarcity.

3.3.1. Economic Impacts

Informal vendors face compounded economic pressures due to climate change, significantly impacting their livelihoods. These include reduced income, increased operational costs, and disruptions to livelihoods caused by extreme weather events and environmental stressors [41–43].

Reduced Working Hours and Customer Reduction

ILO (2018) highlighted that climate change and environmental degradation have already adversely affected jobs and productivity, with projections indicating that these impacts will intensify over the coming decades [2]. For instance, an increase in the prevalence of heat stress cut down on overall labour hours [2]. Studies conducted in South Africa and India reveal that air pollution, heat stress, and extreme weather events lead to decreased customer footfall, reduced working hours, and increased costs associated with relocation or protective measures [1,7–9,41,44]. For instance, heat stress and extreme weather events may lead to reduced customer footfall and increased operational costs [41]. In Harare, Zimbabwe, extreme heatwaves have significantly impacted the livelihoods of informal street vendors, with studies finding that during these periods vendors experienced a marked reduction in working hours due to unbearable temperatures [1,7]. This not only reduced their daily income but also increased their exposure to heat-related illnesses such as heat exhaustion and heatstroke. This highlights the urgent need for adaptive measures to protect vendors from extreme heat.

Lack of Vendors Climate Ready Policy and Financial Support

One notable finding from the review is the dual economic burden faced by informal street vendors due to climate change and inadequate urban policies. Economic barriers, including a lack of access to formal financial support and exclusion from formal urban planning frameworks, were prevalent across regions. Similarly, studies in Latin America and Asia emphasize the financial burden posed by frequent environmental disruptions, such as floods and seasonal variations, which affect vendors' ability to operate sustainably [23–28,42,45–49]. GRAIN (2022) supported this, emphasizing that heavier rains not only disrupt business operations but also increase the financial burden of purchasing protective equipment like tarps and shade structures [6].

Street vendors in the Philippines are frequently affected by typhoons, which cause widespread damage to their stalls and goods. Gerodias and Maratas (2018) reported that after Typhoon Haiyan, many vendors in Iligan City lost their inventory and faced prolonged periods of economic hardship [27].

Studies from other regions, including those by Ko Ko et al. (2020) and Banu et al. (2023), underscored the financial burden posed by urban policy constraints, poor planning, and a lack of access to resources [42,43]. Banu et al. (2023) underscored the economic disruptions faced by informal workers in Kolkata due to COVID-19 and extreme weather, leading to job losses and increased vulnerability [43].

3.3.2. Environmental and Health Impacts

Health impacts emerged as a major area of concern, with respiratory issues, heat stress, and sanitation-related illnesses prominently reported across the studies [9–22,24–28].

The bar chart in Figure 4 illustrates the frequency of words related to occupational exposure and health impacts. “Environmental/environment/environments” (n = 659) and “Exposure” (n = 276) were the most frequently mentioned, indicating a strong focus on environmental exposure and its impacts. Other significant terms included “Impact”

(n = 265), “Pollution” (n = 254), and “Temperature” (n = 331), reflecting the various factors contributing to occupational health risks for informal vendors. Wang et al. (2024) noted that in Beijing, vendors often operate in less desirable locations, resulting in fewer customers and greater exposure to environmental hazards [46].



Figure 4. Number of mentions of Occupational and Environmental Exposure Words.

The bar chart in Figure 5 shows the frequency of health-impact-related words. “COVID” (n = 260) and “Diseases” (n = 232) were the most frequently mentioned, indicating a significant focus on disease prevalence and the impact of the COVID-19 pandemic on health. Other frequently mentioned terms included “Symptoms” (n = 225), “Effects” (n = 234), and “Prevalence” (n = 117), highlighting the detailed examination of health impacts in the reviewed studies.

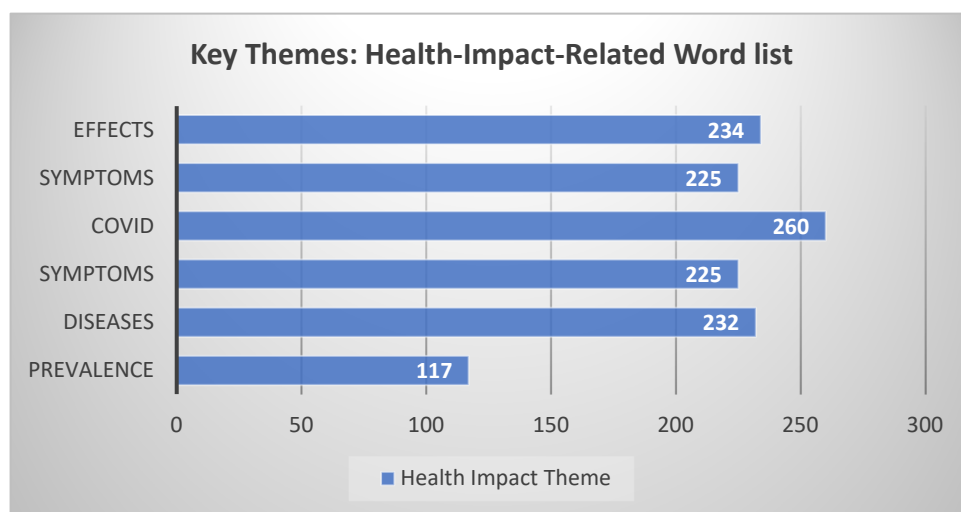


Figure 5. Number of mentions of Health-Impact-related Terms.

Specific Regional Environmental and Health Risks

- Findings from South Africa and other African countries:

The health risks faced by informal vendors are significant and multifaceted. Studies highlighted the severe health impacts of prolonged exposure to air pollution and poor working conditions [9,10,27]. In Warwick Junction, Kwazulu Natal, South Africa, female street traders working under poor environmental conditions exhibited a high prevalence of respiratory illnesses, such as asthma and chronic bronchitis, due to exposure to occupational air pollutants [15]. Sepadi and Nkosi (2023) documented that over 70% of surveyed informal vendors in Johannesburg reported respiratory issues linked to prolonged exposure to PM_{2.5} pollutants [9,10]. These challenges highlight the need for access to personal protective equipment and improved urban air quality management [15].

Similar findings were reported in other African countries. Female street food vendors working in poorly ventilated environments in Egypt reported significant respiratory symptoms, highlighting the need for improved workplace conditions [22]. Erick et al. (2023) highlights the high prevalence of respiratory symptoms among street vendors in Botswana, associated with prolonged exposure to traffic pollutants [17]. In Accra, street traders near traffic hotspots reported high respiratory and cardiovascular symptoms rates, highlighting the severe health impacts of particulate matter pollution [19]. These results are supported by studies conducted outside Africa, such as studies in Thailand and Malaysia reporting that traffic-related air pollution and inadequate protective measures exacerbated respiratory symptoms among street vendors [24,25].

- Findings from other regions:

In another study in Malaysia, Roadside hawkers exhibited decreased lung function and increased respiratory symptoms due to prolonged exposure to traffic-related air pollution [26]. A study in India reported that street vendors exposed to high levels of particulate matter from traffic emissions experienced elevated risks of respiratory health symptoms and long-term health complications [28]. Gerodias and Maratas (2018) reported similar findings in the Philippines, where traffic-related air pollution exacerbates respiratory symptoms among street vendors [27]. They further reported that vendors near major traffic arteries in the Philippines were acutely aware of the health risks. Heat stress was another critical issue. The lack of access to clean water and sanitation facilities compounded these health risks, particularly in low- and middle-income countries.




- Regional Differences

As per Table 3, the regional comparisons revealed variations in the nature and severity of climate change impacts, with vendors in low- and middle-income countries experiencing more pronounced vulnerabilities [10,11,44–46,50–52]. Table 3 below provides a comprehensive overview of the impacts of climate change on informal street vendors, highlighting key factors contributing to their vulnerabilities, associated health outcomes, and adaptation strategies employed to mitigate these challenges. Climate change factors such as flooding, heatwaves, and air pollution disrupt vendors' daily operations, lead to losses of goods, and exacerbate health risks such as respiratory and cardiovascular illnesses.

These impacts are compounded by environmental and infrastructural challenges, including inadequate drainage systems and a lack of shading in markets. Health risks were a major concern across the studies. It was also found that the exacerbation of health inequalities due to climate change impacts vulnerable populations in South Africa [11]. Respiratory health issues from air pollution were prevalent in South Africa, India, and Malaysia. Studies such as those by Gerodias and Maratas (2018) and Yi et al. (2022) identified air pollution and poor working conditions as primary contributors to health vulnerabilities [25,27]. Heat stress, dehydration, and sanitation-related health issues were

commonly reported by women vendors, as evidenced in Venugopal et al. (2016) [44]. However, with weather changes, vector-borne diseases may be primarily influenced by extreme weather events (flooding) that create breeding habitats and extreme temperatures that increase vector activity and reproduction rates. Both factors often interact to exacerbate disease transmission risks. Gender-specific vulnerabilities necessitate targeted policies to mitigate health risks.

Table 3. Regional impacts and adaptation strategies and solutions.

Region	Climate Impacts	Primary Adaptation Strategies and Solutions	Key Challenges	Image Description (Created Using Canva.com Accessed 25 December 2025)
Africa	Flooding, heatwaves, air pollution, vector-borne diseases, high prevalence of respiratory illnesses	Community-driven solutions, participatory action-research, improving sanitation and drainage systems, relocation to less flood-prone areas, shade structures, diversified product offerings	Poor infrastructure, regulatory exclusion, occupational hazards, limited access to financial resources	
Asia	Heatwaves, air pollution, food spoilage, typhoons, water scarcity, respiratory issues, inadequate sanitation	Use of appropriate PPE, urban planning for reduced exposure, shaded areas, diversified product offerings, cooling devices	Gender-specific vulnerabilities, inadequate protective measures, damage to goods from extreme weather	
America	Flooding, food insecurity, economic shocks, regulatory challenges, health risks from air pollution	Income diversification, community-based resilience strategies	Lack of access to resources, economic disruptions	

3.3.3. Gender-Specific Vulnerabilities

Several studies highlighted gender-specific vulnerabilities, emphasizing the unique challenges faced by women vendors. Figure 6 shows that the term “Gender” appeared 224 times, indicating a significant focus on gender-related issues in the context of climate change and informal street vendors. The term “Female” appeared 242 times, slightly higher than “Gender”, emphasizing the experiences and challenges faced by female street vendors. This highlights the need for targeted interventions to support women in the informal economy. The term “Male” appeared 136 times, less frequently compared with “Female” and “Gender”, suggesting a stronger focus on female vendors due to the recognition that women often face more significant challenges and barriers in the informal sector. The high frequency of gender-related terms underscores the importance of considering gender dynamics when addressing the impacts of climate change on informal street vendors. It suggests that gender plays a crucial role in shaping the vulnerabilities and resilience of these vendors. The higher frequency of the term “Female” compared with “Male” indicates that female vendors are a primary focus in the literature, reflecting the recognition of the unique challenges faced by women, such as safety concerns, limited access to resources, and additional caregiving responsibilities.

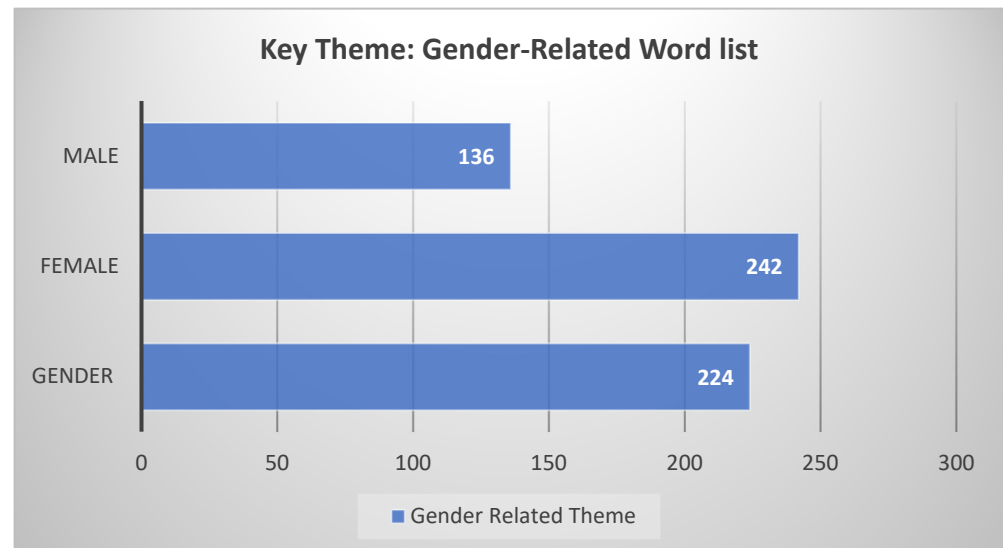


Figure 6. Number of mentions of Gender-related Terms.

Female vendors face distinct challenges that affect their resilience to climate change. Several studies emphasized the unique challenges faced by women vendors, including safety concerns and limited access to resources. Gender-specific vulnerabilities, such as safety concerns and limited access to resources, were also noted, with studies like that by Wang et al. (2024) emphasizing the need for gender-sensitive policies to address these disparities [46]. Women street vendors in Durban face heightened vulnerabilities to climate change impacts, such as heat stress and unpredictable weather patterns, compounded by insufficient infrastructure and legal protections [32]. Women street traders in Cape Town experience compounded vulnerabilities due to inadequate infrastructure and exclusionary urban policies, which intensifies their exposure to environmental risks [13]. Another study on women street food vendors in rural South Africa stated that they are disproportionately affected by climate variability, experiencing heat stress, reduced water availability, and food spoilage. Social networks and small-scale infrastructure improvements, such as cooling systems, have proven essential for their resilience [33].

Prolonged droughts have led to water scarcity, affecting the operations of street vendors who rely on water for their businesses. Venugopal et al. (2016) found that women vendors in particular struggled with the lack of access to clean water, which is essential for maintaining hygiene and preparing food [44]. This emphasizes the intersection of gender-specific vulnerabilities and climate change impacts. Datey et al. (2023) observed that caregiving responsibilities limited women's ability to adapt [44]. These studies emphasize the need for gender-sensitive health interventions to address the specific vulnerabilities of women vendors and improve overall health outcomes for informal workers [44–46]. Advocacy for legal reforms and gender-specific capacity-building initiatives has emerged as a key strategy to enhance their resilience [32].

3.3.4. Policy and Regulatory Operating Challenges

The bar chart in Figure 7 shows the frequency of government- and regulatory-related words. “Political/Politics” (n = 408) and “Vulnerability/vulnerable” (n = 467) were the most frequently mentioned, indicating a strong focus on political and socioeconomic vulnerabilities. Other significant terms included “Trading” (n = 235).

Vendors frequently face exclusionary policies and harassment, which compounded their vulnerabilities. Vendors have faced spatial exclusion and harassment due to hostile urban policies, as seen in studies conducted in South Africa and Uganda [50,51]. Studies

have called for inclusive urban policies that recognize and support the contributions of informal street vendors [50,51].

Young (2018) noted that in Uganda, regulatory harassment forces many vendors into precarious working conditions, while Benit-Gbaffou (2016) argued that South African municipalities frequently neglect to integrate vendors into urban planning frameworks [50,51].

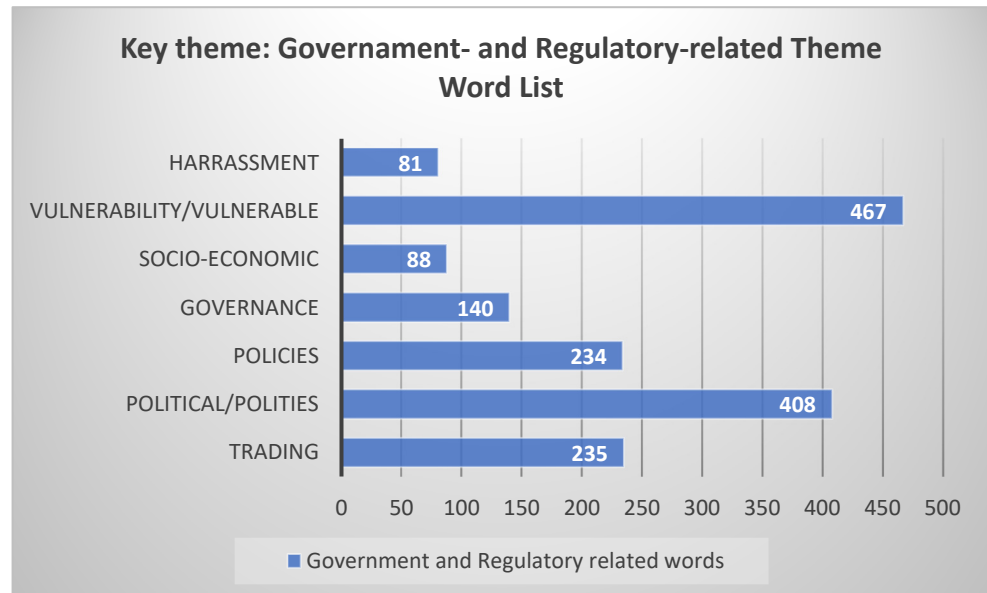


Figure 7. Number of mentions of Government- and Regulatory-related terms.

3.4. Implementable Solutions for Informal Street Vendors

The bar chart in Figure 8 shows the frequency of words related to climate change and adaptation strategies. “Adaptation” and “Strategies” (both n = 309) were the most frequently mentioned, indicating a strong focus on the various methods vendors use to adapt to climate change. Other significant terms included “Security” (n = 168) and “Weather” (n = 168), reflecting concerns about the stability and predictability of weather patterns. “Sustainability” (n = 101) and “Resilience” (n = 93) were also frequently mentioned, highlighting the importance of long-term strategies to ensure the sustainability and resilience of informal street vendors’ livelihoods in the face of climate change.

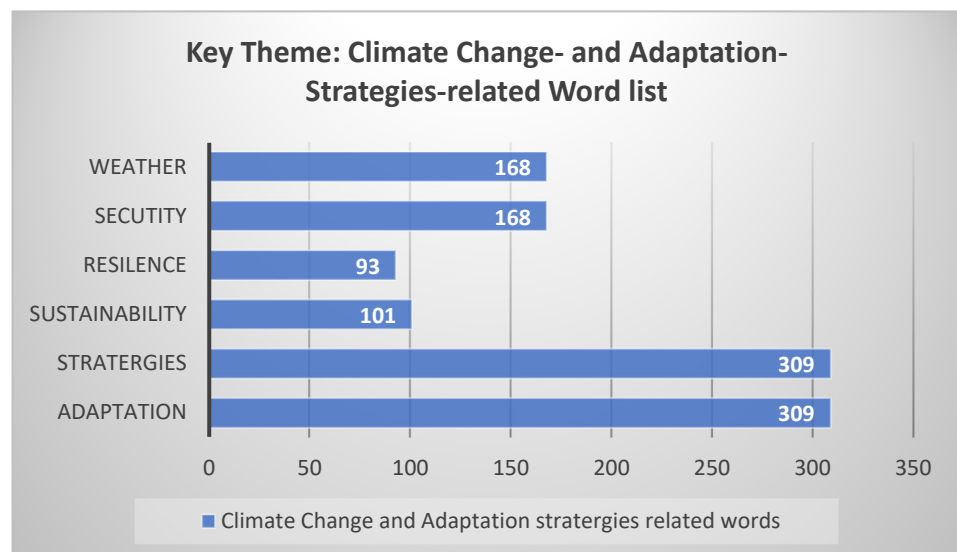


Figure 8. Number of mentions of Climate Change- and Adaptation-Strategy-related terms.

Specific Climate Change Adaptation Strategies and Solutions

Despite these adversities, informal street vendors have demonstrated remarkable resilience through adaptation strategies such as relocating to safer areas, diversifying goods to reduce risk, and using protective gear to safeguard health (Table 3). These strategies varied across regions, with some vendors relying on community support and others adopting technological solutions [46].

- Findings from South Africa and other African countries:

Various adaptation strategies employed by vendors were identified, such as changes in business practices, relocation, and the diversification of goods [7,46,50–52]. In South Africa, vendors face greater challenges from regulatory exclusion and a lack of infrastructure [9,51,53]. In Durban, South Africa, vendor-led improvements in market infrastructure and education on occupational health and safety significantly enhanced the resilience of street vendors to climate-related challenges such as extreme heat and unpredictable weather events [14].

Vendors adopt protective measures and modify their trading methods to mitigate economic risks [54,55]. Sverdlik et al. (2024) emphasized the importance of participatory action research and community-driven solutions to enhance resilience among informal workers in Zimbabwe and India [5]. Additionally, Dodman et al. (2023) found that urban vendors in Zimbabwe were more reliant on informal savings groups to recover from climate shocks [52]. Pasquini et al. (2020) emphasized the need for adaptive urban health strategies to mitigate heat–health impacts in informal settlements in Tanzania [54]. However, these strategies are often constrained by socioeconomic and policy limitations, underscoring the need for systemic support, including improved market infrastructure and inclusive urban policies.

- Findings from other regions:

Vendors often relocate entirely to safer locations [53]. In contrast, vendors in Asia, such as those in Beijing, adopt more technological solutions to cope with climate impacts, as reported by Wang et al. (2024) [46]. These include the use of equipment such as mobile payment systems and cooling devices [2,46]. Turner et al. (2021) documented diverse coping strategies among street vendors in Southeast Asia, including strengthening rural–urban connections and forming vendor solidarity networks [53]. Regional variations in impacts and adaptation strategies were evident (Table 2). The impacts of climate change and the adaptation strategies employed by informal vendors significantly vary across regions. Regional differences in these strategies are evident, with African vendors often relying on community support and Asian vendors adopting more technological solutions, such as portable cooling devices and mobile payment systems [46]. These findings highlight the effectiveness of different adaptation strategies and the importance of context-specific approaches. The regional differences in adaptation strategies have important implications for policy and practice, and they suggest that interventions must be tailored to the specific needs and contexts of vendors in different regions. These findings further underscore the need for targeted interventions that enhance the adaptive capacity of informal street vendors. By focusing on sustainable and resilient practices, vendors can better cope with the adverse effects of climate change and secure their livelihoods.

3.5. Gap Analysis

Several gaps in the existing literature have been identified, highlighting areas for future research. There is a lack of comprehensive data on gender-specific impacts, as noted by Venugopal et al. (2016) and Wang et al. (2024) [44,46]. Additionally, studies have predominantly focused on health and economic impacts, with limited coverage on mental

health or long-term resilience. The role of technology in adaptation strategies is also under-explored. Future research should address these gaps by focusing on comparative analyses across different regions, emphasizing South-to-South collaborations, and exploring the mental health impacts of climate change on informal vendors. Staupe-Delgado et al. (2023) highlight the need for research on temporal adaptations of informal workers to shocks, emphasizing crisis-specific vulnerabilities [55]. Rahaman et al. (2023) call for integrated urban planning to address public health challenges in rapidly urbanizing areas [56]. These areas of research are critical for developing effective interventions and supporting the resilience of informal street vendors in the face of climate change [47,56–58].

4. Discussion

This systematic review highlights the profound and multifaceted impacts of climate change on informal street vendors. The findings were drawn from 48 studies spanning various regions, providing a comprehensive understanding of the challenges faced by these workers and the adaptation strategies they employ [46,47,50–58]. The findings underscore the multifaceted challenges faced by informal vendors, including economic, health, and social vulnerabilities. Adaptation strategies reveal innovative approaches but also highlight systemic barriers.

4.1. How Did Climate Change Affect the Livelihoods of Informal Street Vendors in South Africa from 2015 to 2024?

Climate change has profoundly disrupted the livelihoods of informal street vendors, particularly in South Africa and other regions of the world. Vendors frequently experience reduced income, diminished working hours, and increased costs due to extreme weather conditions. For example, Sverdlík et al. (2024) noted that heatwaves in Zimbabwe and India drastically reduced vendors' working hours [5]. These disruptions not only reduce daily earnings but also lead to higher expenses for adaptive measures such as purchasing umbrellas, moving stalls, or repairing damage caused by flooding [11]. Extreme weather events, such as heatwaves and heavy rainfall, significantly disrupt the operations of street vendors, leading to reduced working hours and decreased customer turnout, directly impacting daily earnings [12–15].

Air pollution has also emerged as a critical factor affecting vendor livelihoods [13]. Vendors operating in high-traffic areas, such as those studied by Gerodias and Maratas (2018) in the Philippines, report chronic respiratory illnesses that limit their productivity [27]. This mirrors findings in Johannesburg, where Sepadi et al. (2023) found PM_{2.5} exposure to be significantly higher among outdoor vendors, exacerbating health-related absences from work [10]. Prolonged exposure to extreme weather exacerbates economic instability, leaving vendors with limited options to financially recover.

Informal settlements, where many street vendors reside, are particularly vulnerable to climate change impacts. A lack of adequate infrastructure exacerbates their susceptibility to extreme weather events, leading to increased health risks and economic instability [59]. The broader socioeconomic implications of these impacts are stark. Vendors often lack financial safety nets or formal recognition within urban economies, as noted by Dodman et al. (2023), which exacerbates their vulnerability to climate-related disruptions [52]. These challenges underscore the compounded impacts of climate change on informal street vendors' livelihoods, requiring targeted interventions.

4.2. What Are the Key Challenges Faced by Informal Street Vendors in South Africa Due to Climate Change?

Informal street vendors in South Africa face unique challenges that intersect sociopolitical, economic, and environmental dimensions. Exclusionary urban policies often marginal-

ize vendors, restricting their access to secure trading spaces and subjecting them to harassment from municipal authorities. Benit-Gbaffou (2016) highlighted how these regulatory barriers exacerbate economic instability, forcing vendors into precarious conditions [50]. While street vendors globally face challenges due to climate change, those in South Africa's informal settlements are uniquely affected by inadequate infrastructure and limited access to services, intensifying their vulnerability compared with counterparts in regions with better urban planning [59]. Similarly, Young (2018) emphasized the sociopolitical exclusion of vendors in Uganda, which parallels experiences in South Africa [51].

Gender-specific vulnerabilities further compound these challenges. Women vendors often balance caregiving responsibilities with their work, limiting their ability to adapt to climate-related disruptions [44].

Environmental challenges such as urban flooding and water scarcity add another layer of complexity. Andersen et al. (2023) reported that vendors in Nairobi's informal settlements frequently lose stock and revenue during floods, a challenge echoed by vendors in cities both in South Africa and all over the world [59]. The lack of basic infrastructure, such as proper drainage systems and designated vending spaces, exacerbates these challenges, making climate adaptation nearly impossible without structural reforms [48,60].

4.3. What Adaptation Strategies Have Informal Street Vendors in South Africa Employed to Cope with Climate Change Impacts?

Despite significant challenges, informal street vendors have demonstrated remarkable adaptability in the face of climate change. Informal vendors have adopted diverse strategies to mitigate the impacts of climate change, though socioeconomic and policy limitations often constrain their efficacy. One common strategy is diversifying their goods to include less climate-sensitive products, as this reduces food security issues. Droughts were identified as a problem because water for washing is necessary for vendor operations [1,7]. Relocation to safer or more profitable locations is another prevalent adaptation strategy [49,53,61]. Vendors in flood-prone areas often move their stalls to avoid environmental hazards.

Community-based support systems, such as informal savings groups, also play a crucial role in enhancing resilience. WEIGO (2020) and the World Resources Institute (2019) emphasized the importance of these networks in providing financial and logistical support during crises [8,62]. In contrast, vendors in Asia have increasingly adopted technological solutions, such as mobile payment systems and portable cooling devices [46]. In Durban, collaborative efforts between informal workers and urban planners have led to the redesign of marketplaces to better withstand climate-related challenges. These initiatives have improved infrastructure resilience, ensuring safer and more sustainable working environments for vendors [62]. These findings highlight the adaptability of informal vendors and the need for targeted interventions to enhance their resilience.

4.4. How Do the Impacts of Climate Change on Informal Street Vendors in South Africa Compare with Those in Other Regions?

Regional comparisons reveal both similarities and differences in how climate change impacts informal street vendors and their responses. In South Africa, vendors face regulatory exclusion and infrastructural deficits that exacerbate their vulnerability to climate shocks [46,50]. In contrast, vendors in Asia frequently cite health impacts, such as respiratory illnesses and heat stress, as their primary challenges [24–28,46].

Adaptation strategies also significantly differ between regions. African vendors heavily rely on community-driven solutions, such as informal savings groups, to recover from climate-induced losses [53]. Vendors often relocate to safer areas during extreme weather events [49]. Meanwhile, Asian vendors have embraced technological innovations, includ-

ing digital payment systems and cooling devices, to mitigate economic and environmental risks [46].

These regional differences underscore the need for localized approaches to supporting informal street vendors. While community-based interventions may work well in Africa, technological solutions could be more effective in regions with better infrastructure. Policymakers must tailor their strategies to address these contextual differences, ensuring that interventions are both inclusive and sustainable. To counter these trends, institutions such as ILO, WEIGO, and the World Resources Institute recommends policies that provide safe vending spaces, access to clean energy, and inclusion in urban governance [2,8,62].

4.5. Implications for Policy and Practice

These results underscore the compounded and intersecting challenges faced by informal street vendors due to climate change. Economic instability, health vulnerabilities, and socioenvironmental barriers are central to their lived experiences, necessitating integrated and regionally tailored interventions. By addressing these multidimensional challenges, policymakers and stakeholders can enhance the resilience and sustainability of informal street vending in the face of climate change. This review aligns with previous studies that emphasize the disproportionate impacts of climate change on informal workers. For instance, GRAIN (2022) and WIEGO (2020) both underscore how extreme weather exacerbates economic instability among street vendors, highlighting similar challenges to those documented in South Africa [6,11].

The findings of this study have significant implications for achieving the United Nations Sustainable Development Goals (SDGs) [35]. Specifically, the study's emphasis on the economic, health, and social challenges faced by informal street vendors aligns with SDG 1 (No Poverty) and SDG 8 (Decent Work and Economic Growth), highlighting the need for targeted financial support and inclusive urban planning to enhance the livelihoods of these workers. The identified health risks, such as respiratory illnesses and heat stress, underscore the importance of SDG 3 (Good Health and Well-being), calling for improved access to healthcare and protective measures for informal vendors. Additionally, the gender-specific vulnerabilities discussed in the study are directly related to SDG 5 (Gender Equality), emphasizing the need for gender-sensitive policies and interventions. Finally, the study's focus on adaptation strategies and resilience-building supports SDG 13 (Climate Action), advocating for integrated approaches to mitigate the impacts of climate change on vulnerable populations. By addressing these interconnected goals, the study contributes to a holistic understanding of how to support informal street vendors in the context of global sustainability efforts.

5. Conclusions

This study highlights the interconnected impacts of climate change on informal street vendors globally, emphasizing the need for tailored regional interventions. Lessons from South Africa and other developing countries in this study can inform broader resilience strategies in similar contexts. Vendors in South Africa are particularly vulnerable to regulatory exclusion, socioeconomic inequities, and gender-specific risks, which exacerbate the impacts of extreme weather events, air pollution, and inadequate access to infrastructure. Vendors in various countries have employed adaptation strategies, such as leveraging community support, relocating to safer areas, diversifying their goods, and adopting technological solutions. These challenges highlight the intersectionality of climate change impacts, as informal vendors navigate sociopolitical, economic, and environmental barriers.

The findings emphasize the need for inclusive urban policies that recognize and address the vulnerabilities of informal workers. Key recommendations include promoting

access to basic services, integrating vendors into urban resilience planning, and supporting gender-sensitive interventions. Future research should explore underexamined areas such as mental health impacts and the role of technology in adaptation strategies. Policymakers must act urgently to bridge gaps in research, policy, and practice to support the resilience and sustainability of informal street vending in the face of climate change.

6. Recommendations and Limitations of the Study

6.1. Recommendations for Street Vendors, Policymakers and Practitioners

Concrete recommendations for street vendors, policymakers, and practitioners based on the findings of this review include:

- **Government Intervention and Inclusive Urban Planning:**

Provision of infrastructure: Integrate informal vendors into urban resilience frameworks to ensure they have access to essential services and infrastructure. This includes providing designated vending areas with adequate shelter and sanitation facilities to protect vendors from extreme weather conditions. For example, providing shaded market spaces in South Africa can address heat-related challenges, while mobile technology training programs, as seen in India, can enhance economic stability.

Reduce air pollution through transportation options: Governments should promote or encourage the use of cleaner, more sustainable transportation options in urban areas by limiting certain streets to only electric vehicles (EVs), as this would create demand for EVs. This means that traditional gasoline- or diesel-powered vehicles would be prohibited from using these streets. While electric cars can be expensive, people who need to use these streets would be more likely to purchase an electric vehicle, whether it is a car, bike, or scooter. Electric bikes (e-bikes) or scooters will be more affordable options for many people when compared to the high cost of an electric car.

Access to Healthcare: Improve access to healthcare services for informal vendors, particularly those exposed to air pollution and extreme heat. Mobile health clinics and health education programs can help address the specific health needs of this population.

Technological Solutions: Promote the adoption of technological solutions, such as mobile payment systems and portable cooling devices, to enhance the resilience of informal vendors. These technologies can help vendors adapt to changing environmental conditions and improve their economic stability.
- **Gender-Sensitive Policies and Solutions:**

Policies: Implement policies that address the unique challenges faced by women vendors, such as safety concerns and limited access to resources. Providing safe and accessible vending locations, as well as targeted financial support, can help women vendors thrive in the face of climate change.

Establishing Daycare Centers for Vendor Streets: To address the caregiving needs of informal street vendors, a practical solution is to establish daycare centers at strategic locations along vendor streets. These centers should be situated near essential facilities such as bathrooms, long washing sinks, and shaded areas, providing safe and convenient places for vendors to leave their children while they work. This setup ensures that children are well-cared for and close by, allowing vendors to focus on their work without the constant worry of caregiving. By improving access to childcare, vendors can increase their productivity and income while fostering a supportive community environment.
- **Vendor Resistance and Community Support:**

Community Support Networks: Strengthen community support networks to provide informal vendors with the social and economic support they need to adapt to climate

change. This can include forming active vendor associations and cooperatives that advocate for the rights and needs of informal workers.

Vendor Resistance: Individual vendors should work together, lobby for these changes, and put in place solutions that serve their needs. Informal street vendors could adapt by practicing various actions, such as acquiring knowledge on the impact of climate change and adopting new solutions for work operations. Furthermore, they can adopt measures such as wearing a mask to lessen exposure to mobile source air pollution or be more resilient by baking in the middle of the night and selling their wares at 7 AM. Cross-regional learning opportunities should also be promoted to exchange best practices.

6.2. Recommendations for Future Research

Future research should explore the intersectionality of vulnerabilities faced by informal workers, particularly in regions like South Asia and Africa where climate change impacts are most pronounced. Comparative studies could offer valuable insights into the best practices for adaptation. Additionally, longitudinal studies focusing on gender-specific impacts would fill critical gaps in understanding the resilience strategies employed by women in the informal economy. Research should also focus on underexplored topics such as mental health and technological adaptation measures relevant to informal street vendors. Future studies and governments are encouraged to pilot the solutions found in these 48 studies and publish their findings.

6.3. Limitations of the Study

The limitations of this research include the relatively low number of relevant documents analyzed, which may have affected the comprehensiveness of the findings. A lack of longitudinal studies and consistent data across regions also limited the review. Additionally, some adaptation strategies may not be generalizable due to contextual differences.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/atmos16020179/s1>, Table S1: Overview of the characteristics of studies in the review.

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Appendix A

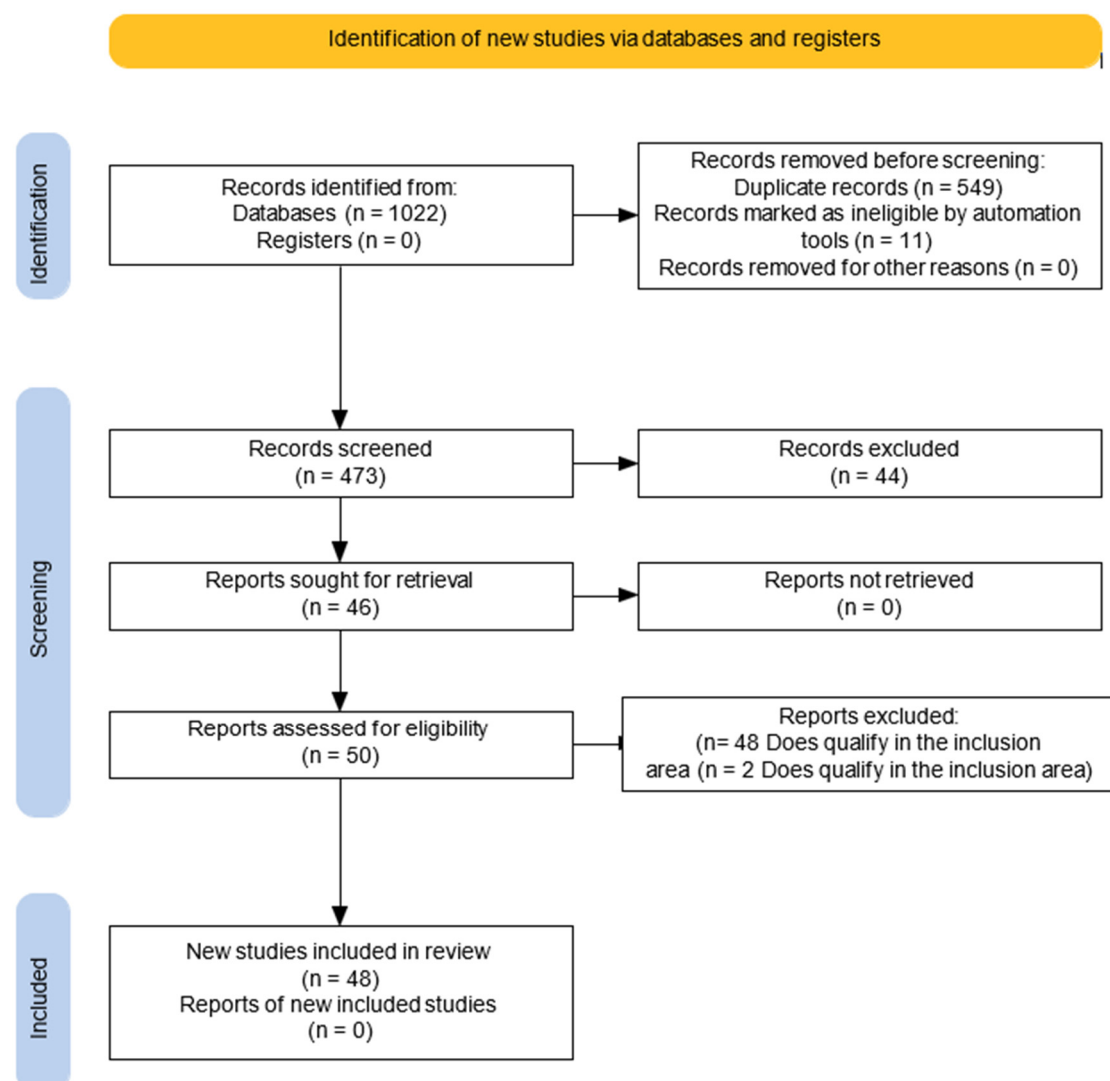


Figure A1. PRISMA flowchart.

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