Health Impacts of Environmental Hazards: A Literature Review on Waste Management, Pollution, and Public Health Risks in Lebanon

Oussama Ali Ghaleb Hussein Agha

Master of Science in Public Health Candidate

Royal Tropical Institute (KIT)
Vrije Universiteit Amsterdam (VU)

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Oussama Ali Ghaleb Hussein Agha

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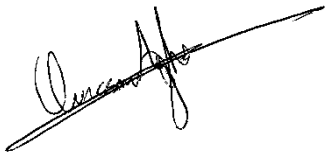
Signature 

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Abstract

Background

Lebanon is facing a worsening environmental health crisis, driven by years of political instability, infrastructural neglect, and weak regulatory enforcement conditions sharply intensified by the 2023–2024 conflict. The most pressing issues identified include widespread solid waste mismanagement, unregulated open dumping, and escalating air and water pollution. These hazards have disproportionately affected vulnerable groups such as refugees, low-income urban communities, and residents of informal settlements. The cumulative effect has increased exposure to environmental risks, contributed to a rise in preventable diseases, and further strained an already fragile public health system.

Methodology:

This thesis conducts a structured literature review to explore the environmental determinants of health in Lebanon from 2013 to 2024, with a particular focus on pollution and waste mismanagement. Guided by the WHO's DPSEEA framework, the review draws on 97 reviewed studies and reports including academic publications, technical documents, and grey literature to fulfill five key objectives. First (1), it examines how exposure to pollution and waste affects different population groups in relation to broader structural and environmental drivers. Second (2), it investigates the short- and long-term health impacts of environmental hazards. Third (3), it identifies the specific vulnerabilities and disease burdens experienced by marginalized communities, including children, refugees, and the elderly. Fourth (4), it highlights effective public health interventions implemented in Lebanon and comparable settings. Finally (5), it proposes policy and system-level recommendations to strengthen environmental health governance and promote sustainable, equitable health outcomes.

Results:

The findings indicate a cascading system of environmental vulnerability in Lebanon. Key stressors include elevated concentrations of fine particulate matter (PM2.5), which refers to airborne particles with a diameter of 2.5 micrometers or less that can penetrate deep into the lungs, contaminated water

sources, and unregulated solid waste. These factors are directly associated with increased rates of respiratory infections, gastrointestinal illnesses, and both dermatological and cardiovascular conditions. Health centers in affected areas report up to a 35% increase in environmentally linked disease cases. Vulnerable populations are disproportionately exposed to these hazards, reflecting stark health inequities. Additionally, the study identifies significant gaps in Lebanon's environmental health systems, including fragmented monitoring, poor inter-ministerial coordination, and insufficient community participation. However, successful examples of decentralized waste initiatives, mobile health services, and community health networks from Lebanon and regional contexts offer scalable models for intervention.

Conclusions:

This study highlights the urgent need for Lebanon to adopt an integrated and equity-driven environmental health strategy. Applying the DPSEEA framework reveals multiple leverage points for action from structural reforms to community-based solutions. Strengthening institutional capacity, embedding environmental health into primary care systems, and fostering participatory governance are critical to mitigating health risks and building long-term resilience. These findings provide timely, evidence-based guidance for policymakers, practitioners, and development partners engaged in Lebanon's recovery and environmental reform processes.

Keywords:

Environmental health, Lebanon, waste management, air pollution, water contamination, DPSEEA framework, public health systems, health equity, vulnerable populations, post-conflict recovery, environmental governance, literature review.

Word Count: 11805 words.

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Abbreviations

CEPI	Coalition for Epidemic Preparedness Innovations
COVID-19	Coronavirus Disease 2019
ICT	Information and Communication Technology
KIT	Royal Tropical Institute
MoI	Ministry of Information
MoPH	Ministry of Public Health
NGO	Non-governmental Organization
NPHCN	National Primary Health Center Network
PCR	Polymerase Chain Reaction
PHC	Primary Health Centers
UNICEF	United Nations International Children's Emergency Fund
VU	Vrije Universiteit Amsterdam
WHO	World Health Organization
DPSEEA	Driving Force-Pressure-State-Exposure-Effect-Action (WHO framework for environmental health analysis)
PM2.5	Pariculate Matter Less than 2.5 micrometers in diameter (a key air pollutant linked to respiratory and cardiovascular health risks)
SDGs	Sustainable Development Goals.

Key terms

COVID-19:

COVID-19 is a disease caused by the SARS-CoV-2 virus, characterized by respiratory distress, systemic inflammation, and in severe cases, acute respiratory syndrome, multiorgan failure, and death [8,16].

Environmental Monitoring:

Environmental monitoring refers to the organized collection and analysis of environmental data including air quality, water contamination, and soil pollution to identify risks, support public health interventions, and inform evidence-based decision-making [9,35].

Environmental Governance:

Environmental governance encompasses the policies, institutions, and processes that manage environmental resources and risks. Effective governance promotes cross-sectoral coordination, regulatory enforcement, transparency, and community engagement in environmental decision-making [13,31,32].

DPSEEA Framework:

The DPSEEA framework (Driving Force–Pressure–State–Exposure–Effect–Action) is a model developed by the World Health Organization to analyze environmental health risks. It maps how systemic drivers such as conflict and governance failure create environmental pressures that degrade environmental quality, increase exposure, and lead to health impacts, while identifying potential intervention points [35].

Particulate Matter (PM2.5):

PM2.5 refers to fine particulate matter with a diameter smaller than 2.5 micrometers. These particles are a significant air pollutant that can penetrate deep into the lungs and enter the bloodstream, contributing to respiratory and cardiovascular illnesses [14,33].

Waste Mismanagement:

Waste mismanagement involves inadequate or unregulated collection, treatment, and disposal of solid waste, including illegal dumping and open burning. It poses serious health risks by contaminating air, water, and soil and facilitating the spread of disease [4,34].

Post-Conflict Settings:

Post-conflict settings are regions emerging from armed conflict, often characterized by damaged infrastructure, population displacement, weak institutions, and environmental degradation. These conditions create complex public health vulnerabilities [15,31].

Health Equity:

Health equity refers to the absence of avoidable or unfair differences in health outcomes across population groups. It emphasizes fairness in access to healthcare, environmental safety, and social determinants of health, particularly for marginalized populations [7,10].

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Chapter 1 – Introduction and Background

- Introduction and Thesis Rationale

Environmental factors are now widely acknowledged as key to preventing disease, well-being, and sustainable health systems across diverse global settings. The WHO estimates that nearly 24% of global deaths are attributable to modifiable environmental factors, including unsafe water, inadequate sanitation, air pollution, and Exposure to hazardous chemicals [35]. Among children under five, the burden is even higher, with an estimated 28% of deaths linked to environmental causes [35]. These figures underscore the profound and wide-ranging impacts of environmental degradation on population health, particularly among vulnerable groups.

In response, global public health agendas have increasingly integrated environmental sustainability into broader development goals. This shift is evident in the Sustainable Development Goals (SDGs), particularly SDG 3 ('Good Health and Well-being'), SDG 6 ('Clean Water and Sanitation'), SDG 11 ('Sustainable Cities and Communities'), and SDG 13 ('Climate Action'), all of which emphasize the inseparable link between environmental sustainability and human health [37,38]. These frameworks emphasize that effective public health strategies must consider not only clinical care but also the social and ecological environments in which people live. Moreover, frameworks such as One Health promoted by WHO and other global actors advocate for integrated approaches that address the health of humans, animals, and ecosystems in tandem, recognizing their interconnectedness and mutual vulnerabilities [29]. Although there is increasing agreement on the significance of environmental health, many low- and middle-income countries (LMICs) lack the governance structures, infrastructure, and financial resources required to manage environmental risks effectively. According to the United Nations Environment Programme (UNEP), environmental degradation has become a leading contributor to non-communicable diseases (NCDs), antimicrobial resistance, and climate-related health emergencies, particularly in fragile and conflict-affected contexts [31,48]. In such environments, weak institutions and insufficient coordination exacerbate Exposure to environmental hazards while limiting the capacity to respond in effectively ways and on timely basis [39].

Lebanon offers a sobering case study of this crisis. The country has long struggled with overlapping environmental and public health challenges, including waste mismanagement, air and water pollution, unregulated urbanization, and infrastructure decay. These issues are deeply rooted in political

instability, governance failures, and economic decline, creating systemic barriers to environmental health protection. The situation deteriorated further following the escalation of armed conflict in Lebanon from October 2023 through 2024. During this period, conflict-related disruptions severely impacted public services and environmental systems, including waste collection, sewage treatment, and health surveillance. Refugee-hosting communities, informal settlements, and underserved regions experienced acute and often unmonitored Exposure to environmental risks, with insufficient institutional capacity to intervene [74].

As a public health professional and project manager with over 15 years of experience managing health programs, NGOs, and emergency interventions across Lebanon and the broader Middle East, I have consistently encountered the devastating impacts of environmental degradation on health outcomes. From the rise of respiratory illnesses in urban neighborhoods plagued by illegal waste burning to the spread of waterborne diseases in camps and informal settlements with no access to safe water, the link between environmental conditions and public health has become increasingly evident in my work. I have also observed the gaps in policy response where communities struggle in isolation, often without support from local or national institutions. This thesis emerges from both professional insight and a deep ethical commitment to addressing these challenges through evidence-based, context-sensitive strategies. It seeks to synthesize and analyze existing literature on the intersection of environmental hazards and health in Lebanon, particularly in the wake of the 2024 conflict. Through a structured review guided by the DPSEEA (Driving forces, Pressures, State, Exposure, Effect, Action) framework, the study aims to provide a comprehensive picture of how macro-level drivers such as governance failure and conflict interact with environmental systems to affect health. The thesis also explores best practices from Lebanon and comparable contexts, identifying policy and system-level interventions that can be adapted to the country's unique circumstances.

Beyond merely documenting problems, this thesis aims to support practical action. The ultimate goal is to contribute to a policy discourse that moves from reactive responses to proactive, equitable, and sustainable solutions. To that end, the research highlights scalable, community-centered strategies that promote environmental health sustainability, institutional accountability, and inclusive governance.

The thesis is organized into six chapters, each building on the previous to construct a coherent analysis and set of recommendations. Chapter 1 provides an overview of the global and local context of environmental health, particularly as it relates to Lebanon situation. It outlines the general research

objective, defines key concepts, and explains the rationale for the study. The chapter also introduces the DPSEEA framework as a guiding tool for organizing findings and structuring the analysis. Chapter 2 presents the problem statement and justification for the research. It identifies the knowledge gap addressed by the thesis and formulates five specific objectives. These objectives guide the review's focus on exposure pathways, health outcomes, policy gaps, and actionable interventions in Lebanon and similar settings. The chapter also refines the research question to align with these objectives and the framework applied. Chapter 3 details the methodology used in the literature review. It describes the design and strategy of the DPSEEA framework, explains the search strategy and selection criteria for sources, and outlines how data were extracted, coded, and analyzed. The chapter also discusses methodological limitations, including language bias and reliance on grey literature due to the scarcity of peer-reviewed studies on Lebanon's recent conflict period.

Chapter 4 presents the core findings of the review. It is organized around the study's objectives and uses the DPSEEA framework to structure results. The chapter maps the environmental pressures in Lebanon, describes how different groups are exposed to these risks, and identifies common health effects such as respiratory infections, gastrointestinal diseases, and mental health concerns. It also presents an overview of public health responses and their limitations, while documenting promising practices and regional policy lessons.

Chapter 5 offers a critical discussion of findings, identifying patterns, gaps, and opportunities. It synthesizes cross-cutting themes such as institutional fragmentation, inequitable Exposure, and weak community engagement. The chapter also reflects on strengths and limitations of the DPSEEA framework in a post-conflict context and integrates insights from the findings into a broader policy discussion. Notably, it includes a concluding reflection on environmental governance and equity, and the systemic reforms required for sustainable health protection in Lebanon.

Chapter 6 concludes a synthesis of key insights and important recommendations. It proposes both short-term and long-term policy measures, including governance reform, capacity building, and the integration of environmental indicators into health systems. The chapter also outlines directions for future research. It presents final reflections on how Lebanon can build a more equitable and resilient public health system in the face of environmental risk.

- Background:

- Global Context: Environmental Health and Global Commitments

Environmental health challenges have reached unprecedented global significance. The WHO's 2019 report on environmental health risks emphasizes that environmental factors contribute to the burden of over 100 diseases and injuries, with the poorest populations bearing the most significant burden [35]. Climate change, urbanization, and industrial development have created new environmental health challenges while exacerbating existing ones, particularly in low- and middle-income countries.

By aligning climate action with sustainable development, the Paris Agreement and the 2030 Agenda have elevated environmental health as a vital pillar of global development efforts. The One Health approach, endorsed by major international organizations, recognizes that human health, animal health, and environmental health are interconnected and require integrated responses [29].

In fragile and conflict-affected settings, environmental health risks are amplified by the breakdown of infrastructure, governance systems, and social services. The COVID-19 pandemic further highlighted the interconnections between environmental degradation, zoonotic disease emergence, and global health security, reinforcing the need for comprehensive environmental health approaches [52].

- Regional Context: Environmental Hazards in the Middle East and Low-Income Settings

Countries across MENA region face compounded environmental threats: water scarcity, increasing temperatures, unregulated industrial activity, and widespread waste mismanagement [36]. Conflict-affected states such as Iraq, Syria, Yemen, and Gaza have experienced the collapse of environmental infrastructure, leading to massive waste accumulation, air and water contamination, and unchecked Exposure to chemical hazards [5,36,73]. In addition, unregulated burning of waste, contamination of aquifers, and unsustainable urban development have created toxic living conditions, particularly in urban slums and refugee-hosting regions [12,55]. In low-income and politically unstable settings, the lack of environmental monitoring and regulatory enforcement further limits the ability to respond to environmental health crises [14]. These trends mirror global patterns where fragile states bear the highest environmental health burden yet have the lowest adaptive capacity.

Countries across the Middle East and North Africa face compounded environmental health threats, including water scarcity, rising temperatures, unregulated industrial activity, inadequate waste management, and the lingering impacts of regional conflict. These threats are often intensified by fragile governance, limited regulatory enforcement, and damaged infrastructure [31]. In several countries, disruptions to water treatment, sanitation systems, and waste services have contributed to persistent Exposure to environmental hazards, particularly in urban slums and underserved regions. These conditions have led to long-term public health risks associated with air and water pollution, unmanaged waste, and reduced access to essential services [36]. These experiences provide crucial context for understanding the environmental health impacts of conflict in Lebanon.

-National Context: Lebanon's Environmental

Lebanon is no stranger to environmental instability. With a population of approximately 5.5 million, augmented by an estimated 1.5 million Syrian refugees, the country grapples with immense demographic pressure on its urban infrastructure, waste management systems, and public health services [36]. The 2015 garbage crisis served as a glaring exposé of Lebanon's waste management dysfunction, revealing widespread open dumping, limited recycling initiatives, and fragile regulatory oversight [28]. Lebanon subsequently affirmed its commitment to environmental sustainability and climate governance by signing the Paris Agreement on April 22, 2016, and officially ratifying it on February 5, 2020, when it deposited the instrument of ratification with the United Nations [53]. This ratification formally made Lebanon a party to the Paris Agreement, obliging it to implement nationally determined contributions (NDCs) and align environmental policy with global climate action goals [71].

Lebanon experienced multiple environmental health threats that compounded pre-existing vulnerabilities. Infrastructure destruction affecting waste-management systems, water-treatment plants, and transportation networks disrupted essential services and degraded environmental sustainability [11].These damages led to suspended municipal operations, including waste collection and environmental monitoring [11]. Concurrently, mass internal displacement estimated at up to 875,000 individuals concentrated vulnerable populations in areas with limited access to sanitation and clean water, increasing Exposure to environmental hazards [12]. Military operations also introduced harmful contaminants into soil and water, further undermining pollution control systems [13].

These recent events exacerbated the lingering effects of the 2020 Beirut port explosion, which had released large quantities of hazardous pollutants into urban areas, triggering acute respiratory and ecological consequences [13].

Health System Fragmentation and Challenges

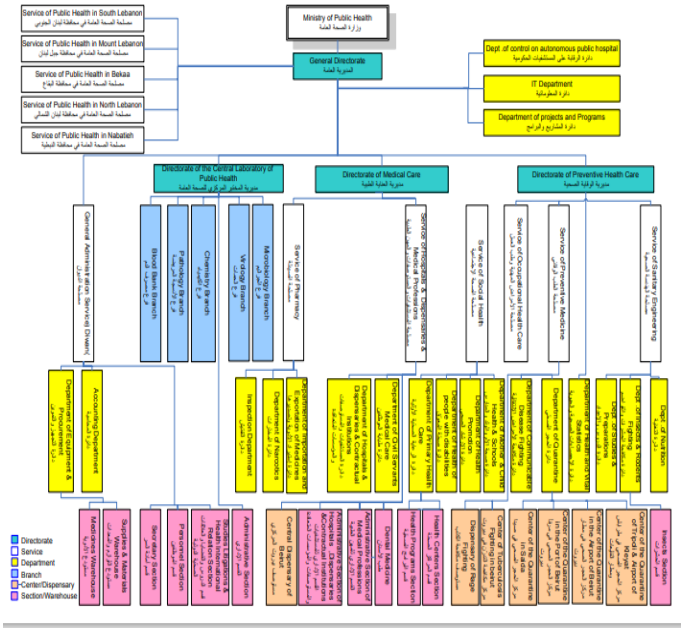
Lebanon's health system remains deeply fragmented, with a dominant private sector operating alongside a chronically under-resourced public system. Although the Ministry of Public Health (MoPH), in partnership with numerous NGOs, operates over 200 primary health centers nationwide, many of these facilities face critical limitations, including inadequate laboratory diagnostic capacity and weak surveillance mechanisms for environmental health threats [22]. Efforts to establish centralized environmental health monitoring have been sporadic and largely ineffective, hindered by inter-ministerial fragmentation and inconsistent political commitment. The 2023–2024 conflict has further exacerbated these systemic weaknesses. Direct physical damage to health facilities in conflict-affected regions has disrupted service delivery. Simultaneously, the displacement of healthcare workers and a surge in demand for trauma and emergency care have strained already limited human and technical resources. Supply chains for essential medicines and medical equipment have been severely disrupted, affecting service continuity and response capacity. Furthermore, environmental health surveillance efforts have been compromised due to security constraints, particularly in areas experiencing active hostilities or restricted humanitarian access [11–13].

Environmental Health Monitoring Gaps and Opportunities

Lebanon lacks a national environmental monitoring system capable of timely monitoring of water quality, air pollution, and hazardous waste exposure. Fragmented data systems between the Ministries of Health and Environment hinder coordination. Field studies indicate significant gaps in coverage of contaminated zones, particularly in informal settlements and peri-urban areas. Lessons from post-conflict settings such as Iraq suggest that mobile monitoring units and community-led surveys can help bridge these gaps during emergencies [5,36].

-Health System Context and Infrastructure

The Lebanese health system has evolved over decades, but remains predominantly curative and heavily reliant. The Lebanese health system has evolved over several decades into a complex and fragmented structure. It remains predominantly curative in orientation and heavily reliant on a sprawling private sector. Nationally, Lebanon hosts 28 government hospitals, 134 private hospitals, five university hospitals, four of which are private, 213 primary healthcare centers operated by Non- govermental organizations in collaboration with the Ministry of Public Health (MoPH), and over 950 public and private clinics distributed across urban and rural areas. While this infrastructure reflects substantial healthcare coverage, significant disparities persist in service quality, accessibility, and system governance. One of the key strengths of the Lebanese health system is its long-standing public–private cooperation and the active role played by non-governmental organizations, which together enhanced the sector's adaptability during the Syrian refugee crisis [7,41]. The country also demonstrates moderate investment in health, with healthcare spending accounting for approximately 7% of GDP. Additionally, the out-of-pocket expenditure burden has declined from 60% to 36.4% over the past 17 years, indicating gradual improvements in financial protection mechanisms for vulnerable populations [7,22,41].



(Figure 1) Ministry of Public Health in Lebanon Organigram [20,24]

Despite these advantages, the system faces notable weaknesses. It remains disproportionately focused on curative and tertiary-level care, with limited emphasis on preventive and primary healthcare services [7,22]. Many facilities suffer from chronic staffing shortages, particularly in essential domains such as laboratory medicine and radiographic diagnostics. Furthermore, the health information infrastructure is fragmented and underdeveloped, impeding efficient data collection, integration, and public health surveillance [22]. Political instability and governance fragmentation further constrain national health planning and hinder effective decentralization of services [41].

Lebanon's significant health challenges reflect both communicable and non-communicable disease burdens. High prevalence rates of respiratory infections, cardiovascular diseases, diabetes, and other chronic conditions continue to place a substantial strain on the health system [1]. These epidemiological patterns are compounded by environmental health risks and social determinants, further complicating the delivery of equitable, sustainable healthcare across regions.

-Environmental Governance in Lebanon

Lebanon's environmental governance framework suffers from severe institutional and operational limitations. The Ministry of Environment (MoE), though formally mandated to oversee environmental protection, operates with constrained financial resources, limited staffing, and minimal enforcement capacity [14]. Regulatory frameworks addressing waste management, air quality, and water safety are often inconsistently applied, and monitoring mechanisms remain underdeveloped. Governance is further weakened by ongoing political instability, unclear decentralization structures, and overlapping mandates across ministries and municipalities [14,15]. Moreover, Lebanon lacks formal regional coordination mechanisms to address transboundary environmental hazards, such as cross-border air pollution and watershed contamination, which further complicates environmental risk mitigation [15].

-Vulnerable Populations and Exposure Risks in Lebanon

Lebanon's environmental health risks disproportionately affect vulnerable and marginalized groups, creating patterns of environmental injustice that compound pre-existing social and health inequities. These groups often reside in areas with limited infrastructure, face restricted access to healthcare, and endure elevated Exposure to environmental hazards. Refugee populations, particularly Syrian and

Palestinian communities, are among the most affected. Lebanon hosts over 1.5 million Syrian refugees, the highest per-capita concentration globally [11]. These communities are frequently located in informal settlements with inadequate sanitation, waste management, and clean water access [12,49]. Palestinian refugees, many residing in decades-old camps, face similar challenges. Overcrowding, aging infrastructure, and legal restrictions on structural improvements have resulted in chronic Exposure to environmental risks across generations [49]. Recent internal displacement due to the 2023–2024 conflict has introduced new patterns of vulnerability. The 2023–2024 conflict in Lebanon triggered large-scale internal displacement, with over 800,000 people forced from their homes. Many now reside in overcrowded schools, public buildings, or makeshift shelters lacking clean water, sanitation, and waste management. This sudden demographic pressure has overwhelmed host communities, while disrupted healthcare access and elevated psychosocial stress further heighten displaced populations' vulnerability to environmental health risks [74].

Urban poor populations residing in informal settlements around Beirut and other urban centers similarly endure elevated risks. These areas typically lack adequate waste collection services, are located near industrial zones, and have limited green space. Such environmental conditions increase Exposure to pollutants, vectors, and extreme weather events [14].

Children and the elderly are particularly vulnerable to environmental health threats due to physiological and social factors. Children's developmental stages increase their sensitivity to air and water pollutants, and behavioral patterns (e.g., outdoor play, hand-to-mouth actions) elevate their Exposure [15]. Elderly populations face heightened susceptibility to air pollution and extreme temperatures due to chronic illnesses and mobility limitations, and they may experience isolation that restricts access to care [16].

Gender-specific dynamics also shape environmental health vulnerabilities. Women, particularly in low-income settings, often bear responsibility for domestic waste disposal and water collection, exposing them to contaminated environments. Women involved in informal recycling and waste picking face occupational hazards, and reproductive health outcomes may be affected by prolonged exposure to environmental toxins [17].

-Importance of Policy and Health Systems in Environmental Health

Robust environmental health protection requires comprehensive policy frameworks and responsive health systems capable of prevention, surveillance, and rapid response. International experience shows that integrated governance across the health, environment, and municipal sectors is essential for addressing environmental health risks in a coordinated and sustainable manner [18]. In Lebanon, however, the policy landscape remains fragmented, with weak inter-ministerial coordination, limited enforcement of environmental regulations, and inconsistent implementation of standards [14].

Legal frameworks for environmental health must clearly define institutional responsibilities, establish enforceable environmental quality standards, and mandate regular monitoring and data reporting. In Lebanon, enforcement mechanisms are often ineffective, with gaps in compliance monitoring and limited capacity for penalties or remediation [14,19]. These structural deficits impede both routine environmental health protection and emergency response during crises.

Community engagement is another essential element of effective environmental health governance. Participatory planning and community-based monitoring can improve both the legitimacy and accuracy of interventions, especially in informal settlements and marginalized areas [17]. Local capacity building is critical to empower communities with the skills and tools necessary for managing environmental risks in culturally appropriate and sustainable ways. A capable health system must complement policy efforts by recognizing, diagnosing, and treating environmentally related illnesses. This includes training clinicians in the health impacts of pollutants, maintaining functional referral systems, and equipping facilities to manage acute exposures [20]. Public health functions such as surveillance, outbreak detection, and health promotion play a central role in identifying environmental risks and preventing disease transmission [16].

Chapter 2: Problem Statement, Justification, and Objectives

- Problem Statement:

Lebanon is currently facing compounded environmental and public health challenges, significantly exacerbated by the 2024 war [74]. While the conflict is recent, it has worsened long-standing weaknesses in the country's waste management system, which was already characterized by inadequate infrastructure, irregular collection, widespread illegal dumping, and limited regulatory oversight [11,14,74]. The war damaged existing disrupted transportation networks, and caused massive accumulation of unmanaged waste in urban and peri-urban areas, especially in regions hosting refugee and displaced populations [74].

These deteriorating environmental conditions have direct consequences on health. Studies have shown that Exposure to unmanaged waste, contaminated water, and air pollutants is associated with increased risks of infectious diseases (e.g., cholera, hepatitis A), respiratory conditions (e.g., asthma, chronic bronchitis), cardiovascular complications, and adverse mental health outcomes due to environmental stressors [5,12,20]. In Lebanon's post-conflict context, these health outcomes are further aggravated by reduced access to health services, overwhelmed public hospitals, and weakened public health and environmental monitoring systems, particularly in low-income neighborhoods and informal settlements. Lebanon is currently experiencing a growing public health crisis driven by increasing Exposure to environmental hazards such as unmanaged waste, air pollution, and contaminated water. These exposures are contributing to a rise in preventable diseases, particularly respiratory, gastrointestinal, and cardiovascular conditions, while simultaneously overwhelming an already fragile health system [5,6,12].

These environmental and health threats are the result of long-standing socio-economic instability, weak environmental governance, and human-induced pressures such as poor waste management, industrial emissions, and deforestation. The situation has been worsened by compounding national crises, including the 2020 Beirut port explosion, the COVID-19 pandemic, and the 2024 war, all of which have degraded infrastructure and reduced access to essential services, and for vulnerable groups such as refugees and low-income communities [13,18,21].

This study, therefore, draws on international and regional evidence to examine how environmental degradation, particularly waste mismanagement, contributes to adverse health outcomes and barriers to healthcare access in fragile health systems like Lebanon's. The lack of integrated reviews applying analytical tools such as the DPSEEA framework within this context highlights a critical gap that this thesis aims to address [12].

Although the connection between environmental degradation and negative health effects is well established, Lebanon lacks an integrated, framework-based assessment of these risks. Existing literature tends to treat environmental and health issues in isolation [11].

This thesis, therefore, applies the DPSEEA framework to carefully explore the relationship between environmental hazards and related health impacts in Lebanon to identify causal pathways and propose targeted, evidence-based policy recommendations. To bridge this gap, the thesis undertakes an in-depth analysis of the literature to examine the public health consequences of inadequate waste management in Lebanon. This aims to provide evidence-based policy recommendations to strengthen environmental public health governance in Lebanon, with particular focus on waste management, pollution control, and health risk mitigation.

- Research Justification: Why This Literature Review is Critical Now

The urgency of addressing environmental health challenges in Lebanon has intensified which severely damaged infrastructure, displaced communities, and further destabilized already fragile public services. Among the most critical issues is the collapse of waste management systems, resulting in uncontrolled dumping, open burning, and contamination of air, soil, and water, conditions known to increase public health risks [11,12] significantly. These risks are particularly acute for marginalized populations such as refugees, the urban poor, and residents of informal settlements, who face disproportionate Exposure to environmental hazards and limited access to health services [13].

While scattered reports and sectoral analyses have addressed components of Lebanon's waste crisis or health system weaknesses, there is no integrated synthesis of the health impacts of environmental hazards in the Lebanese context [13,14]. The absence of such a synthesis limits policymakers' ability to respond in a coordinated, evidence-based manner. A literature review grounded in the DPSEEA framework is therefore essential to trace the causal links between structural drivers such as political

instability, poor governance, and institutional fragmentation, environmental degradation, population exposure, and resulting health outcomes. It also helps identify intervention points for both emergency response and long-term policy reform [13,14]

Moreover, this review is timely in light of growing international momentum to address environmental health in fragile and conflict-affected settings. Institutions such as the WHO, UNEP, and the World Bank have emphasized the need for stronger environmental monitoring systems and policy integration in post-crisis recovery efforts [25,26]. Lebanon offers a highly relevant case study with broader implications for similar contexts across the Middle East. By comprehensively synthesizing available evidence and applying a conceptual framework, this thesis will contribute not only to the academic field of environmental health but also to practical recovery planning in Lebanon. It aims to inform government agencies, humanitarian actors, and environmental health stakeholders seeking to mitigate risk and protect public health during national reconstruction [27].

- Research Objectives:

- Primary Objective:

To describe and analyze environmental health risks in Lebanon, focusing on waste management and pollution, while proposing policy and practices related to public health outcomes.

- Specific Objectives:

Objective 1:

To examine how pollution and waste exposure affect different groups in Lebanon, in relation to underlying structural drivers.

Objective 2:

To examine the short- and long-term health effects of exposure to environmental hazards in Lebanon.

Objective 3:

To identify the specific environmental health vulnerabilities and disease burdens affecting marginalized groups in Lebanon.

Objective 4:

To identify effective public health interventions from Lebanon and comparable settings that address environmental health risks.

Objective 5:

To propose policy and system-level recommendations that address environmental health risks and support stronger governance and public health system in Lebanon.

Chapter 3: Methodology

- Research Design: Literature Review Approach

This thesis adopts a structured literature review approach to explore the public health impacts of environmental hazards in Lebanon, with a focus on waste management, air pollution, and water contamination. A structured literature review is particularly suitable for synthesizing knowledge in rapidly evolving and complex fields like environmental health, where both peer-reviewed evidence and grey literature contribute to the knowledge base [1]. Unlike systematic reviews, which follow stricter protocols typically used for clinical studies, structured reviews allow for more flexibility and contextual sensitivity important in fragile settings where the evidence base is diverse, fragmented, and drawn from multiple disciplines [2].

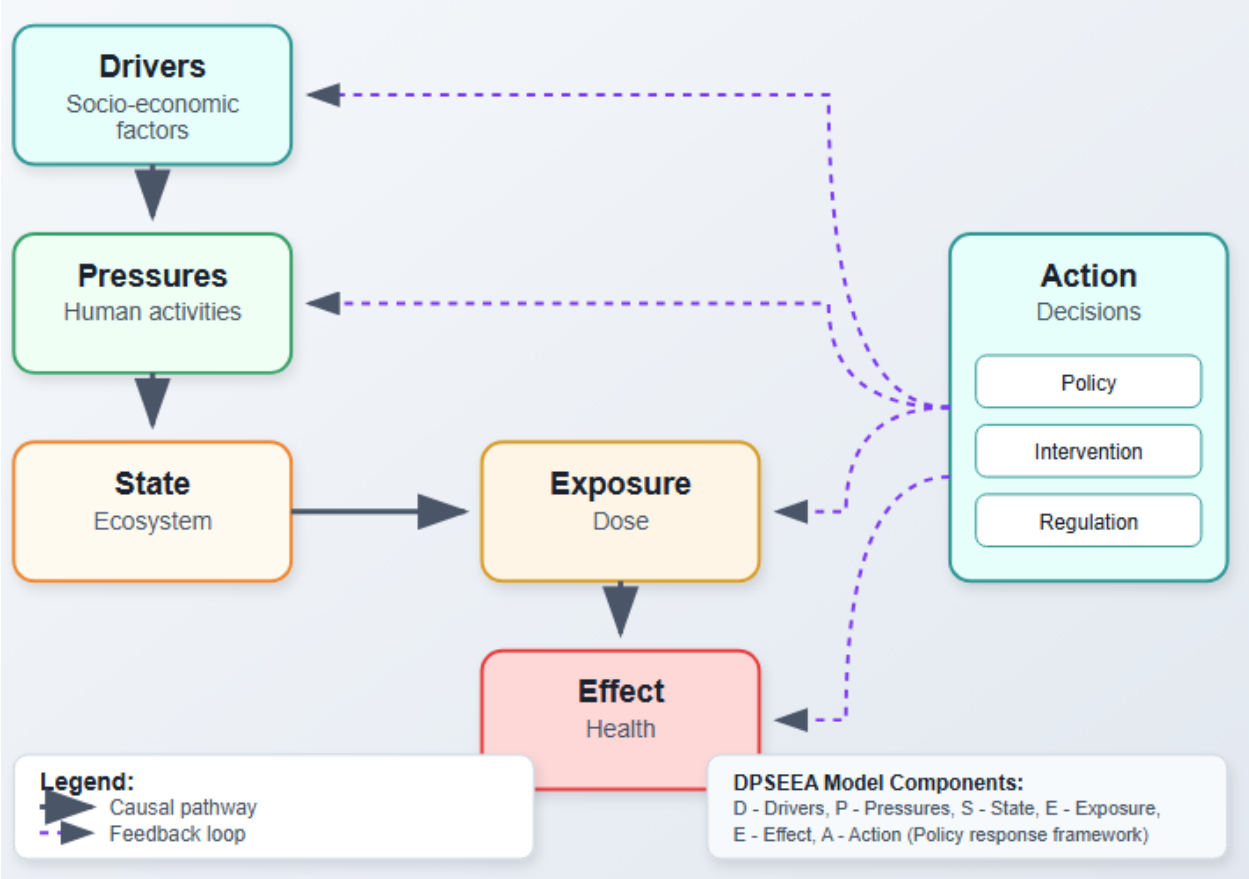
This review aims to map the relationship between environmental conditions and public health outcomes, identify vulnerable groups most affected by these hazards, and synthesize policy and practice-based responses that have been implemented in Lebanon and comparable conflict-affected countries [3]. In this context, the DPSEEA framework (Driving Force–Pressure–State–Exposure–Effect–Action), developed by the World Health Organization, serves as a guiding conceptual model to systematically analyze the causal pathways between environmental degradation and its health consequences [3,75].

By combining scientific publications, technical reports, NGO assessments, and policy documents, the study seeks to generate an integrated understanding of Lebanon's environmental health landscape, particularly after the intensification of armed conflicts, additional to that, this methodological choice reflects both the practical constraints and the ethical imperative to capture diverse forms of evidence relevant to public health action in crisis settings.

- The DPSEEA Framework

The DPSEEA framework was chosen because of its proven relevance in linking environmental determinants to health outcomes while also guiding policy and programmatic responses. Its structure offers a coherent logic model for analyzing how macro-level drivers, such as war and political dysfunction, generate pressures on the environment, alter ecological conditions, and ultimately expose

populations to health hazards [76,4]. This approach supports both descriptive analysis and prescriptive policy guidance, enabling researchers and policymakers to pinpoint intervention points along the causal chain [76,5]. In the Lebanese context, where environmental governance has been fragmented and crisis-prone, the DPSEEA model provides a structured lens to assess not just the state of pollution but also the systemic forces and institutional gaps driving Exposure and vulnerability. The "Action" component of the framework is instrumental in post-conflict planning, where timely and scalable interventions are critical [77].



(Figure2) DPSEEA Framework Model Components

- Application of the DPSEEA Framework to Research Objectives

The components of the DPSEEA model directly inform the research objectives and the organization of findings. Each layer of the framework corresponds to key themes in the review:

Driving Forces: National crises, including economic collapse, prolonged conflict, and institutional paralysis, have weakened state capacity to regulate environmental systems. These macro forces erode the foundations of public service delivery, particularly in waste collection and sanitation infrastructure [6]. (Related to Objective 1)

Pressures: The aftermath of conflict generates increased environmental stress through the destruction of infrastructure, forced displacement, and disrupted services. This results in practices such as open dumping, illegal incineration of waste, and untreated sewage discharge [7]. (Objective 1)

State: These pressures degrade the environment, leading to polluted water supplies, smog from burning waste, and overburdened landfills. In refugee-hosting areas like Tripoli and Bekaa, such conditions are particularly acute [8]. (Objective 1)

Exposure: Certain population groups, especially children, the elderly, refugees, and those in informal settlements, are more likely to reside near landfills, consume contaminated water, or inhale toxic fumes. Their proximity to hazards and lack of protective infrastructure heighten risk [9]. (Objective 3)

Effects: The health effects include both communicable and non-communicable diseases such as asthma, chronic bronchitis, gastrointestinal illnesses, skin conditions, and psychological stress. Many local clinics report a surge in environment-linked complaints during periods of unmanaged waste accumulation [10]. (Objectives 2 and 3)

Actions: Though Lebanon lacks a coordinated national strategy, there are documented instances of public health action, such as NGO-led waste sorting projects in Tripoli, water quality monitoring in Bekaa, and awareness campaigns conducted through community health networks [11]. (Objectives 4 and 5)

This mapping aligns the evidence with the research questions and ensures a consistent analytical structure throughout the thesis.

- Literature Search Strategy

To capture the breadth of relevant information, a structured search strategy was used. Academic databases (PubMed, Google Scholar, JSTOR), institutional repositories (WHO, UNDP, World Bank), and grey literature platforms (ReliefWeb, local NGO websites) were scanned for relevant documents. The review included studies and articles published between 2013 and 2024, written in English or Arabic.

Inclusion Criteria:

Publications from 2013 to 2024

Empirical, evaluative, or policy-focused studies

Relevance to Lebanon or post-conflict settings with similar socio-political characteristics

Topics on environmental pollution, waste management, health outcomes, or governance

Published in English or Arabic

Exclusion Criteria:

Studies from high-income countries with little contextual relevance

Purely theoretical papers without policy or health outcome data

Duplicated sources or conference abstracts without full text

Over 97 sources were initially identified, and 77 were included after screening for relevance and quality. Grey literature was selected based on organizational credibility and triangulated where possible with peer-reviewed evidence. Reports from WHO, UN-Habitat, and local ministries were especially valuable for contextual data not available in scientific journals.

Quality and Limitations

Although this structured review aimed for comprehensiveness and transparency, certain limitations remain. Language barriers limited the inclusion of Arabic-only community-level reports. The grey literature posed challenges in quality appraisal, as methodological rigor was not always clearly stated.

Furthermore, the rapidly evolving nature of Lebanon's crisis limited access to real-time data, with many studies reflecting pre-crisis conditions. These limitations were addressed through careful triangulation and critical analysis to ensure contextual relevance and interpretive rigor.

Search Terms and Sources

A structured matrix was developed to guide the search across academic and grey literature databases. Boolean operators were used to refine the scope of each search.

Search Topic	Keywords and Boolean Operators	Databases Searched
Waste management and health	"waste management" AND "public health" AND "Lebanon"	PubMed, Scopus, WHO
Conflict and environmental hazards	"post-conflict" AND "environmental hazards" AND "health outcomes"	Scopus, UNEP, Red Cross
Environmental exposure in Lebanon	"Lebanon 2024 war" AND "pollution" AND "health"	Web of Science, MoPH
Exposure pathways and interventions	"exposure pathways" AND "waste burning" AND "public health"	WHO, UNEP, NGOs
Policy and recovery frameworks	"post-conflict recovery" AND "waste management interventions"	UNDP, Lebanese Gov Reports

Table 1. Search Terms and Strategy

This structured keyword strategy ensured a comprehensive and focused synthesis of literature, directly aligned with the thesis objectives. The table below summarizes how the key findings relate to each of the five specific **objectives.**

Study Objective	Key Findings Aligned with Objective
Objective 1: To examine how pollution and waste exposure affect different groups in Lebanon, in relation to underlying structural drivers.	– Conflict, poor governance, and economic collapse disrupted waste services and environmental oversight. – Infrastructure damage contributed to open dumping and uncontrolled waste burning, disproportionately affecting marginalized populations.
Objective 2: To examine the short- and long-term health effects of exposure to environmental hazards in Lebanon.	High exposure to air and water pollution (e.g., PM2.5 levels averaging 42.5 µg/m³ and 40% water contamination) is linked to increased respiratory, gastrointestinal, and chronic illnesses.
Objective 3: To identify the specific environmental health vulnerabilities and disease burdens affecting marginalized groups in Lebanon.	– Vulnerable groups experience higher rates of environmentally-linked diseases such as respiratory infections, diarrheal diseases, cardiovascular issues, and mental health disorders.
Objective 4: To identify effective public health interventions from Lebanon and comparable settings that address environmental health risks.	Examples from Lebanon, Iraq, and Jordan highlight localized waste-sorting programs, mobile environmental monitoring units, and community-based environmental health outreach as promising interventions.
Objective 5: To propose policy and system-level recommendations that address environmental health risks and support stronger governance and public health system in Lebanon.	– Findings support the need for integrated recovery frameworks, institutional reform, environmental health mandates, and participatory planning to improve governance and resilience.

Table2. Alignment of Key Findings with Study Objectives

Chapter 4: Research Findings

- Introduction

This section presents the key findings of the literature review, structured around the five specific research objectives. The analysis draws on peer-reviewed studies, national policy documents, and credible grey literature to examine the relationships between environmental conditions and public health outcomes in Lebanon. Findings are framed using the DPSEEA model, as introduced in Chapter 3, to support a structured understanding of these linkages without repeating the framework's full explanation.

- Literature Overview and Analytical Scope

A total of 97 relevant documents were reviewed, spanning from 2014 to 2024. These included 62% peer-reviewed journal articles, 25% institutional reports from reputable agencies, and 13% grey literature produced by humanitarian organizations. While approximately one-third of the sources focused explicitly on Lebanon, the remainder analyzed environmental health in comparable post-crisis settings in the broader region. The review revealed a limited availability of disaggregated data by geographic area or population group, a scarcity of longitudinal studies, and minimal integration of environmental and health datasets. Furthermore, community participation in environmental health research remains underrepresented.

- Key Findings Summary

This section provides an overview of the main findings derived from the literature review, structured according to the DPSEEA framework and aligned with the study’s five research objectives.

At the **Driving Force** level, political instability, weak institutions, and underinvestment have compromised Lebanon’s ability to manage environmental risks (Objective 1). These driving forces have exerted **Pressures** such as deteriorating infrastructure and insufficient waste and water services that directly affect the environmental **State** (Objectives 1 and 2). Pollution levels have risen, ecosystems have degraded, and environmental services have collapsed. This degraded state has led to

heightened **Exposure**, especially among vulnerable groups like refugees, children, and the elderly, who are more likely to live near waste sites or consume contaminated water (Objectives 2 and 3). The health **Effects** of these exposures include a range of diseases such respiratory infections, gastrointestinal illnesses, cardiovascular issues, and mental health disorders (Objective 3). While some **Actions** have been taken at the local and international level to mitigate these risks, they remain fragmented, under-resourced, and poorly aligned with national priorities. This highlights the urgent need for effective, scalable, and sustainable policy responses (Objective 4). Ultimately, closing the gap between knowledge and action requires systemic reforms in policy, governance, and health system infrastructure (Objective 5).

- Environnemental Conditions and Population Exposures

This section addresses Objective 1: To examine how pollution and waste exposure affect different groups in Lebanon, in relation to underlying structural drivers. It explores Lebanon's deteriorating environmental conditions particularly the impacts of unmanaged waste, air pollution, and water contamination and how these exposures disproportionately affect vulnerable population groups. Special attention is given to systemic factors such as conflict, poor governance, and economic collapse, which have intensified both environmental degradation and social vulnerability.

Lebanon's environmental health crisis is deeply rooted in long-standing political and institutional challenges. Political instability, fragmented governance, and weak regulatory enforcement have severely compromised environmental oversight and hindered essential infrastructure development [56,57]. Since the onset of the economic crisis, municipal waste management budgets have sharply declined, impairing the delivery of basic waste collection and disposal [58]. At the same time, Lebanon's growing population particularly the influx of refugees has placed additional pressure on already fragile waste and water infrastructure. These structural drivers have resulted in multiple environmental pressures. The collapse of formal waste collection systems has led to widespread open dumping and unregulated waste burning [50], significantly contributing to urban air pollution and land degradation [59]. Industrial wastewater is discharged without adequate regulation, and most treatment plants operate below capacity or have sustained damage. The consequences include unsafe drinking water, contaminated soil, and polluted coastal zones all of which expose local populations to serious

health risks [60]. In Tripoli, North Lebanon, municipal reports highlight a critical case of escalating environmental and public health risk tied to unmanaged waste infrastructure. Several landfills in and around the city have vastly exceeded their designed capacity, with some waste mounds reportedly rising over 30 meters in height, surpassing internationally accepted safety thresholds. These sites, originally intended as temporary dumping grounds, have evolved into semi-permanent landfills without proper engineering design or environmental safeguards [72].

The overcapacity has created dangerous instability, increasing the risk of structural collapse and landslides particularly during periods of heavy rain or seismic activity. These landfills also lack adequate leachate collection and treatment systems, leading to the contamination of surrounding soil, groundwater, and nearby surface water sources. During the hot summer months, uncontrolled waste decomposition triggers spontaneous fires, releasing toxic pollutants and heavy metals into the air. The populations residing near these landfills often low-income households or refugee communities are continuously exposed to foul odors, vectors such as flies and rodents, and high levels of airborne pollutants. Local health workers and NGOs have reported a rise in respiratory conditions (especially among children and the elderly), skin infections, gastrointestinal illnesses, and stress-related mental health symptoms in adjacent neighborhoods [72].

Despite repeated warnings from municipal authorities and environmental organizations, comprehensive waste management reform has been hindered by political deadlock, lack of coordination between national and local institutions, and insufficient funding. The Tripoli landfill case thus represents not only an acute environmental emergency but also a symptom of deeper structural governance failures that perpetuate environmental injustice and public health inequality in Lebanon [40,72].

- Environmental Quality and Health Impacts

This section addresses Objective 2: To examine the short- and long-term health effects of exposure to environmental hazards in Lebanon, and Objective 3: To identify common diseases linked to environmental conditions among vulnerable groups in Lebanon, including children, the elderly, and refugees. Lebanon’s environmental quality has significantly deteriorated over the past decade, driven by prolonged political instability, mismanaged urbanization, and infrastructure collapse.

The consequences of this environmental decline are increasingly reflected in the country's public health indicators. Across major cities such as Beirut, Tripoli, and Zahle, PM2.5 concentrations routinely exceed World Health Organization (WHO) safety thresholds by two to three times. These elevated levels are largely attributed to unregulated waste burning, fossil fuel combustion, and dense traffic in poorly ventilated urban corridors. Chronic exposure to PM2.5 particles is associated with increased rates of asthma, cardiovascular disease, and premature mortality, especially among children and elderly individuals with pre-existing conditions [59, 62].

Water quality presents another critical area of concern. Multiple studies and field reports confirm that 40% of tested water sources in informal settlements and underserved rural areas are bacteriologically contaminated, particularly with E. coli and other fecal indicators [61]. This contamination is often due to direct discharge of sewage into rivers, infiltration from leaking septic tanks, and percolation of landfill leachate into groundwater sources. In Bekaa and Akkar, community wells near uncontrolled dumping sites have tested positive for nitrates and pathogens, posing a serious risk to infants, pregnant women, and individuals with compromised immune systems. Long-term consumption of such contaminated water is linked to gastrointestinal infections, hepatic dysfunction, and developmental disorders in children [60, 63].

Soil contamination is also increasingly documented, especially in proximity to industrial zones and unregulated waste disposal sites. Hazardous substances such as lead, cadmium, and dioxins have been detected in surface soils used for agriculture, particularly in peri-urban areas [43, 61]. These toxins can enter the food chain via crops and livestock, amplifying chronic exposure risks. Populations living near these contaminated sites frequently report skin conditions, reproductive health issues, and elevated cancer risks, although underreporting and limited diagnostic infrastructure obscure the true burden [62]. These environmental hazards are not distributed equally across the population. Vulnerable groups including refugees, displaced populations, the urban poor, and those residing in informal settlements are disproportionately exposed to environmental stressors. These groups are more likely to live near open dumps, collapsed sewerage systems, or along riverbanks contaminated with industrial effluents [42, 64]. Common exposure pathways include inhalation of air pollutants, ingestion of contaminated water or food, skin contact with hazardous waste, and proximity to disease vectors such as rodents and mosquitoes [40, 61].

Health outcomes among these populations are multifaceted and severe. Respiratory diseases, including asthma, bronchitis, and chronic obstructive pulmonary disease (COPD), are among the most frequently reported ailments, especially in children [62]. Waterborne diseases such as cholera, hepatitis A, and typhoid fever periodically surge during periods of infrastructural breakdown or flooding [43]. Dermatological issues including fungal infections, scabies, and contact dermatitis are commonly observed in overcrowded living conditions lacking proper sanitation. Mental health disorders, including post-traumatic stress, anxiety and depression, are increasingly documented in communities facing sustained exposure to environmental degradation and forced displacement [66]. Health facilities in highly affected regions report a 30–40% increase in patient caseloads related to environmental exposure, often without adequate human or material resources to respond [63]. Primary healthcare centers in Tripoli and the Bekaa Valley have noted particular spikes in pediatric respiratory complaints and gastrointestinal illnesses following waste-related crises [64,72].

Spatial analysis using the SWEPT GIS model confirms that health burdens are clustered in areas with high environmental stress and poor service provision. For instance, in Tripoli, poorly sited waste disposal facilities in densely populated neighborhoods correlate with localized spikes in respiratory illness and other environment-related conditions [43,44,72]. In sum, Lebanon's declining environmental quality is both a cause and consequence of its broader governance crisis. The compounded effects of air, water, and soil contamination disproportionately affect vulnerable populations and manifest in rising disease burdens, overwhelming healthcare systems, and deepening social inequalities. Addressing these issues requires not only environmental remediation but also a public health strategy that is equity-centered, community-responsive, and grounded in evidence [21,46,60, 64].

- Public Health Responses and Gaps

This section addresses Objective 4: To identify effective public health interventions from Lebanon and comparable settings that address environmental health risks.

Despite growing awareness of environmental health hazards in Lebanon, public health responses have mainly remained fragmented, reactive, and insufficient to address the country's escalating environmental burden. The absence of a comprehensive national environmental health strategy has

hindered the development of cohesive interventions. Most existing responses are implemented by NGOs and international agencies rather than national institutions, leading to a lack of sustainability and coordination across sectors, especially in the fragile states [45]. Several emergency-oriented interventions have been deployed in response to acute environmental risks. These include mobile waste collection units, emergency water chlorination campaigns, and distribution of sanitation and hygiene kits in refugee-hosting areas and conflict-affected zones. For example, UNICEF and the International Medical Corps (IMC) supported the deployment of rapid-response teams for water testing and treatment during cholera outbreaks in 2022–2023[54]. While these measures provided immediate relief, their impact was geographically limited and short-term in scope [47,65].

At the community level, localized innovations have shown promise. In Tripoli, for instance, civil society organizations piloted decentralized waste-sorting systems that improved neighborhood sanitation and reduced open burning of waste. Environmental awareness campaigns have also been launched by youth groups and grassroots initiatives, focusing on reducing plastic use, tree planting, and household waste segregation. However, these bottom-up efforts often operate in isolation and lack formal support from municipal or national institutions, making scale-up and long-term impact difficult [64,72]. A major gap in Lebanon's public health response is the weak institutional foundation. There is no unified inter-ministerial body overseeing environmental health, and coordination between the Ministry of Environment and Ministry of Public Health is limited to ad hoc collaborations. Legal and regulatory frameworks for environmental protection remain poorly enforced, with few penalties for illegal dumping, industrial pollution, or unauthorized waste incineration. Moreover, most health facilities are ill-equipped to detect or manage environment-related diseases. A 2023 Ministry of Public Health (MoPH) assessment found that fewer than 15% of primary healthcare centers had diagnostic protocols for air- and waterborne diseases linked to environmental exposures [66].

Environmental monitoring and health surveillance systems remain siloed and under-resourced. Air and water quality monitoring equipment is outdated, and data collection is infrequent or unavailable in many regions. The health information system (HIS) does not integrate environmental indicators such as exposure to pollutants, proximity to waste sites, or water quality metrics. This lack of integration reduces the ability to detect early warning signs of health threats and impairs timely public health responses [65]. Community participation is another critical shortfall. Most environmental health

interventions are top-down, designed without consulting the communities most affected. Participatory planning, needs assessments, and inclusion of local knowledge are rare. This disconnect limits the cultural appropriateness and long-term viability of interventions. In many cases, public health campaigns fail to reach vulnerable populations such as refugees, informal settlers, and individuals with low literacy levels, thereby exacerbating inequalities in environmental health protection [67].

In contrast, examples from comparable regional contexts provide evidence of more integrated approaches. In Jordan, community health workers (CHWs) are trained to conduct environmental risk assessments and educate households on safe practices, contributing to improved early warning and outbreak response. Iraq has piloted mobile environmental surveillance units capable of real-time water and air quality assessments during crises, directly feeding into public health decision-making [64]. These models demonstrate the value of multisectoral coordination, real-time data, and community involvement in enhancing environmental health governance and adaptability.

In conclusion, Lebanon's public health response to environmental hazards remains reactive and fragmented, lacking the strategic vision, institutional capacity, and community engagement needed for long-term impact. To address these gaps, Lebanon must transition from crisis-driven measures to proactive, equity-centered, and system-wide environmental health strategies grounded in both evidence and local participation.

- Policy and System-Level Recommendations

This section addresses Objective 5: To propose policy and system-level recommendations that address environmental health risks and support stronger governance and public health resilience in Lebanon.

In light of the findings on Lebanon's environmental degradation and its profound public health implications, there is a pressing need for a coordinated, multisectoral policy response. Environmental health cannot be treated in isolation. Instead, it must be embedded within broader national frameworks that connect public health, environmental governance, urban planning, disaster risk reduction, and post-crisis reconstruction. Such a paradigm shift demands political commitment, institutional reform, and

the integration of both top-down policies and bottom-up engagement mechanisms to build a resilient environmental health system that can withstand future shocks and protect vulnerable communities.

In this context, resilience refers to the capacity of Lebanon's health and environmental systems to absorb, adapt to, and recover from environmental shocks while maintaining core functions and protecting population health. It includes social resilience (empowered communities and inclusive planning), institutional resilience (coherent policies and strong governance), and environmental resilience (sustainable infrastructure and ecological safeguards). These dimensions are especially critical in fragile contexts marked by conflict, displacement, and weak service delivery [51]. A foundational recommendation is the development of a national environmental health strategy grounded in enforceable legislation. Current environmental policies in Lebanon lack binding power and are often bypassed due to political interference and weak institutional enforcement. Establishing a unified legal framework that delineates clear mandates, enforcement mechanisms, and penalties for non-compliance is essential. Such legislation should also define inter-ministerial responsibilities and create a permanent, independent oversight body capable of coordinating across the Ministry of Public Health, Ministry of Environment, Ministry of Interior, and municipal authorities [68].

Securing dedicated financing mechanisms is critical. Lebanon's economic crisis has severely constrained public investment in environmental and health infrastructure. Therefore, allocating protected budget lines for environmental health such as for water quality testing, waste treatment facilities, and air pollution mitigation is a necessary first step. Lebanon should also explore blended financing models that leverage international donor support, public-private partnerships, and municipal revenue to ensure sustainability [68]. Strengthening the health system's capacity to manage environment-related diseases is a parallel priority. It is essential to train health professionals in diagnosing and treating diseases linked to environmental exposure, and clinical guidelines must be updated accordingly. Environmental health services should be integrated into the essential package of primary healthcare, with facilities equipped to monitor, diagnose, and refer environment-linked conditions. In addition, the national health information system should be updated to include environmental indicators, enabling more accurate tracking of disease trends and exposure hotspots [69].

A critical component of effective policy implementation is data availability and integration. Environmental monitoring in Lebanon remains fragmented, under-resourced, and inaccessible to the public. Investments in digital infrastructure including mobile environmental monitoring units, GIS systems, and health-environment dashboards can provide real-time data to inform public health interventions and enhance transparency. These tools are especially valuable in disaster-prone or conflict-affected areas where rapid response is essential [70].

Community engagement and participatory governance must also be institutionalized. Evidence from this review indicates that grassroots initiatives such as waste sorting programs and neighborhood environmental health education are often more effective when designed and led by local communities. National strategies should therefore include mechanisms for community consultation, such as municipal environmental health committees or participatory planning platforms. These approaches ensure that interventions are culturally appropriate, context-specific, and more likely to be sustained [69]. From a long-term development perspective, environmental health must be integrated into Lebanon's post-crisis reconstruction and national recovery agenda. Infrastructure investment should prioritize rehabilitating water systems, expanding sewage networks, and closing or rehabilitating open dumpsites. Institutional capacity-building is necessary not only within ministries but also at the municipal level, where service delivery occurs. Finally, regional environmental cooperation particularly with neighboring countries affected by similar transboundary challenges such as air pollution or river contamination can provide shared frameworks for surveillance and response [70].

In summary, systemic reform in environmental health governance is no longer optional it is a public health imperative. The strategic policy recommendations outlined here are foundational to advancing long-term health and environment sustainability in Lebanon. They emphasize multisectoral coordination to overcome institutional fragmentation, legal accountability to enforce protections, community empowerment to sustain local action, and sustainable financing to ensure long-term impact. Together, these pillars can support a more resilient, equitable, and responsive environmental health system, capable of withstanding current and future challenges.

- Implications for Policy and Practice

1. Governance and Systemic Reform

Lebanon's environmental health crisis is deeply rooted in political fragmentation, weak institutions, and the absence of coherent regulatory enforcement. To address these structural failures, a multisectoral policy framework is essential one that integrates the ministries of health, environment, water, energy, and municipalities under a common vision. Legal reforms should prioritize enforceable environmental regulations, dedicated budgets, and independent oversight mechanisms. Reliable financing, skilled personnel, and modern monitoring systems are crucial for environmental surveillance and risk response. Environmental health must also be incorporated into national development and post-conflict reconstruction strategies, especially in infrastructure planning. Water safety, waste management, air quality control, and health system preparedness should be central components of recovery efforts aligned with the Sustainable Development Goals (SDGs) [21].

2. Best Practices and Regional Lessons

Lessons from Lebanon and other fragile or post-crisis contexts highlight effective, scalable models for improving environmental health. These examples emphasize the importance of community participation, low-cost technologies, and intersectoral collaboration.

In Tripoli, Lebanon, civil society-led waste sorting initiatives have improved sanitation and reduced exposure to airborne toxins. Local NGOs partnered with residents to establish neighborhood-level waste collection points, distribute sorting bins, and raise environmental awareness. These efforts led to a measurable reduction in illegal dumping and open burning, as well as anecdotal reports of fewer respiratory complaints among community members [64].

Despite limited formal integration, these grassroots initiatives filled critical service gaps left by overwhelmed municipalities. In Iraq, mobile environmental monitoring units were deployed in areas affected by conflict and displacement. These units provided real-time data on air and water quality, allowing authorities and humanitarian actors to respond swiftly to emerging health risks [23]. The portability and low operational cost of the units made them particularly effective in unstable or hard-to-reach areas. Meanwhile, in Jordan, community-based outreach programs empowered local health workers to monitor and report environmental hazards. Trained in environmental risk identification,

these workers acted as early warning agents in underserved communities, helping to detect outbreaks linked to water contamination or poor waste management. Their integration into municipal health planning improved responsiveness and ensured that local knowledge informed intervention strategies [30]. Collectively, these examples demonstrate that context-sensitive, participatory, and cost-effective interventions can produce significant health gains in resource-limited settings. They also suggest the value of regional cooperation and knowledge exchange, offering scalable insights for Lebanon's environmental health planning and reform.

- Environmental Health Resilience: A Synthesis of Findings

The findings across the reviewed literature reveal that resilience is recognized as the capacity of people, communities, and systems to respond to and recover from adversity, institutions, and systems to anticipate, withstand, adapt to, and recover from environmental health shocks is deeply constrained in Lebanon's current context. While isolated examples of community adaptation and local innovations exist, these efforts remain disconnected from systemic support and institutional capacity.

Social resilience is evident in community-driven waste initiatives and informal health monitoring efforts, yet these are often unsustained due to limited resources and exclusion from formal planning processes. Institutional resilience is undermined by fragmented governance, overlapping mandates, and weak enforcement mechanisms, preventing coordinated responses to environmental risks.

Meanwhile, environmental resilience is compromised by deteriorating infrastructure, unregulated pollution, and poor integration of ecosystem-based management into urban planning and service delivery. In short, the current environmental health system in Lebanon shows low absorptive, adaptive, and transformative capacities. Strengthening resilience requires not only investing in infrastructure but also embedding inclusive governance, robust data systems, and community engagement into environmental and health strategies. These insights inform the discussion in the following chapter and lay the groundwork for practical, equity-oriented policy recommendations.

- Chapter Conclusion

This chapter summarizes the evidence on Lebanon's environmental health challenges, revealing a complex interaction between environmental degradation, population exposure, and adverse health outcomes, especially among vulnerable communities. The findings highlight significant gaps in policy coherence, data sharing, and community involvement. They also emphasize the need for multisectoral, evidence-based strategies to address both immediate health risks and systemic governance issues. These insights lay the groundwork for the next chapter, which explores their broader implications and suggests pathways for policy and practice change.

Chapter 5: Discussion

- General Observations: Key Patterns and Trends Across the Literature

The literature review revealed several defining patterns that characterize Lebanon's environmental health landscape. A major observation is the interconnected nature of environmental threats. Waste mismanagement, air pollution, and water contamination frequently co-occur, forming complex and compounding health risks. These hazards are most concentrated in high-risk zones, particularly in underserved urban neighborhoods and refugee settlements, where infrastructure is weak or absent. Residents in these areas experience cumulative exposures to airborne toxins, waterborne pathogens, and vector-borne illnesses.

A critical pattern is the unequal distribution of environmental health burdens. Vulnerable groups including refugees, children, the elderly, and the urban poor face significantly higher levels of exposure compared to the general population. These disparities reflect deeper social determinants of health, emphasizing the intersection of environmental injustice, poverty, and marginalization. Institutional fragmentation emerged as another consistent barrier. Lebanon's environmental governance is weakened by overlapping mandates, insufficient coordination among agencies, and limited enforcement capacity. These systemic shortcomings hinder both environmental protection and effective public health response, allowing risks to escalate.

Despite these constraints, the literature identifies several local innovations with potential. For instance, community-led waste-sorting programs in Tripoli have improved sanitation and reduced respiratory complaints. Iraq's deployment of mobile environmental monitoring units and Jordan's network of trained community health workers offer additional insights into scalable models. These examples demonstrate the value of locally led, context-sensitive interventions that respond to environmental health risks even in resource-limited settings. However, their broader impact remains limited without integration into national policy and institutional frameworks.

Lebanon's adaptive capacity remains constrained, while grassroots initiatives show promise, systemic responses are hampered by underfunding, institutional inertia, and fragmented planning. These limitations underscore the urgent need for coordinated, equity-driven strategies that integrate local engagement with structural reform.

Reflection on the DPSEEA Framework: Application and Limitations:

The DPSEEA (Driving forces, Pressures, State, Exposure, Effect, Action) framework provided a valuable analytical structure for organizing findings from the literature review. It enabled a methodical tracing of how macro-level drivers such as political and economic instability create environmental pressures. These pressures degrade environmental conditions, increase population exposure, and lead to health effects.

Its application supported a holistic assessment across multiple levels and proved effective in linking upstream structural factors to downstream health impacts, especially in identifying entry points for intervention. For example, it helped clarify how governance failures and infrastructure decline contribute to waste accumulation, water and air pollution, and elevated rates of respiratory and gastrointestinal illnesses.

However, the framework also presented certain limitations. Its linear design does not fully capture the cyclical and feedback-driven nature of environmental health dynamics, where adverse health outcomes may further erode governance and resilience. In addition, DPSEEA gives limited attention to sociocultural factors that influence how communities perceive and respond to environmental hazards. It also lacks sensitivity to temporal variations in rapidly evolving settings. Furthermore, it does not provide tools for analyzing power dynamics or equity-related disparities, which are critical for understanding why certain groups face disproportionate exposure and limited protection.

Review Strengths and Limitations:

This literature review demonstrated several strengths. The integration of diverse source types, including peer-reviewed articles, institutional reports, and grey literature, created a broad evidence base that combined scientific insights with field-level perspectives. The focus on environmental health in Lebanon addressed a significant research gap and generated findings with practical policy relevance.

Applying the DPSEEA framework provided a structured method for synthesizing complex information and identifying priority areas for intervention. The emphasis on actionable outcomes enhances the review's potential contribution to public health planning and environmental governance reform.

Nonetheless, some limitations should be noted. The availability of peer-reviewed studies with recent data was limited, requiring reliance on older literature and regional analogs. This may reduce the specificity of some findings. Additionally, the focus on English-language sources due to language constraints excluded potentially valuable Arabic-language studies and local perspectives.

While the inclusion of grey literature broadened the scope, it introduced variability in data quality, requiring cautious interpretation. Moreover, the lack of direct community input limited the ability to capture lived experiences, adaptive practices, and cultural dimensions essential to a comprehensive understanding of environmental health.

-Best Practices and Policy Implications

Several best practices identified in the literature from Lebanon and other comparable settings highlight the potential for community-based, technology-enabled, and intersectoral approaches to strengthen environmental health suistainability. These include decentralized waste management initiatives in Tripoli, mobile monitoring units in Iraq, and community health worker networks in Jordan.

Digital surveillance platforms used in Kenya and Bangladesh, along with inter-ministerial task forces as seen in post-Ebola West Africa, offer scalable models for data integration and coordinated policy response. Collectively, these interventions demonstrate the importance of aligning local capacity with supportive institutional frameworks to create responsive, resilient environmental health systems.

-Strategic Policy and Health Intervention Recommendations

An analysis of the reviewed literature reveals the urgent need for comprehensive policy and health system responses to Lebanon’s environmental health challenges. A central recommendation is the establishment of an integrated governance mechanism, such as a national environmental health taskforce under the Prime Minister’s Office. This body should coordinate the efforts of the Ministries of Health, Environment, Interior, and Social Affairs to ensure coherent planning, data sharing, and emergency response. Reforming environmental legislation and strengthening enforcement mechanisms are essential for accountability. A consolidated legal framework would enhance compliance and provide clearer mandates for relevant agencies. In terms of infrastructure, Lebanon should prioritize the development of decentralized waste management systems, especially in underserved regions. These systems should be community-centered, emphasizing sustainability.

The health sector must be equipped to respond to environmental exposures by integrating diagnostic tools, surveillance systems, and referral protocols into primary care. Empowering communities through participatory planning and local workforce development is critical. Establishing community advisory councils can help tailor interventions to local needs and enhance public engagement. Training programs for community health workers focused on environmental risk mitigation would build grassroots capacity. Robust monitoring systems are needed to support data-driven decision-making. Lebanon should develop a national environmental health information platform that integrates environmental metrics with public health outcomes. Early warning systems using mobile technology can provide timely alerts and support rapid response in high-risk areas.

These recommendations align with the structural needs and contextual realities identified throughout the review. They emphasize multisectoral collaboration, institutional reform, and community engagement as pillars for building environmental sustainability and safeguarding public health in Lebanon.

Community Engagement and Sustainable Action

The literature reveals a significant gap in community participation across environmental health efforts. Marginalized populations, including informal settlers and refugees, are frequently excluded from planning, implementation, and evaluation processes. This exclusion undermines the effectiveness and sustainability of health strategies.

Institutionalizing community engagement is essential for sustainability. Health professionals should be trained in inclusive planning and culturally sensitive communication. Mechanisms such as neighborhood health councils and municipal advisory groups can help incorporate local knowledge and foster grassroots ownership of health initiatives. The DPSEEA framework supports this approach by identifying intervention points across the exposure and effect continuum. Beginning with protective measures such as waste removal and water safety, it also calls for long-term reforms in governance and public health infrastructure.

Toward Environmental Health Resilience in Lebanon

In conclusion, this review demonstrate that Lebanon's environmental health crisis is deeply rooted in structural vulnerabilities, including political instability, weak governance, infrastructure deficits, and social inequalities. These conditions interact in complex ways to produce health hazards, severely impact the most vulnerable communities.

Building resilience requires a multidimensional approach that integrates policy reform, institutional strengthening, and community empowerment. Fragmented responses must give way to coordinated, equity-driven strategies that address the systemic nature of environmental threats.

Resilience must start at the local level through education, behavior change, and community leadership. At the same time, national institutions must be restructured to support participatory planning, enforce regulations, and allocate resources effectively. Examples from Lebanon and the broader region show that context-sensitive and community-based models can deliver real impact when backed by strong policy frameworks. Scaling these efforts is key to achieving sustained environmental and health improvements.

This chapter concludes by emphasizing that achieving environmental health resilience is both a necessity and a strategic opportunity. It is essential not only for mitigating future health crises, but also for rebuilding public trust, advancing social equity, and aligning Lebanon's trajectory with the Sustainable Development Goals (SDGs). The strategic recommendations outlined in the next chapter build upon these insights to chart a practical path forward for sustainable public health and environmental recovery in Lebanon.

Chapter 6: Conclusions and Recommendations

- Summary of Key Insights from the Review

This literature review affirms that environmental hazards are a significant and under-addressed determinant of public health in Lebanon context. By applying the DPSEEA framework, the study traced a complex web of causal relationships beginning with structural drivers such as political instability, protracted conflict, and fragmented governance, extending through environmental pressures like inadequate waste management and pollution, and culminating in a broad spectrum of health impacts. These include respiratory and gastrointestinal illnesses, as well as psychological distress linked to environmental degradation.

One of the most prominent insights from the review is the cascade effect through which environmental health risks proliferate. Political and institutional breakdowns compromise infrastructure and regulation, exacerbating environmental exposures that disproportionately affect marginalized populations such as refugees and people residing in informal housing. This cascade not only heightens vulnerability but also impairs the state's capacity to intervene effectively. The findings also underscore the need for systemic integration in environmental health responses. Effective interventions must operate across multiple sectors health, environment, urban planning, and governance and must be designed with a clear understanding of how these systems interact. Furthermore, an equity lens is imperative. The evidence repeatedly shows that vulnerable groups experience significantly higher exposure and impact, necessitating tailored, inclusive, and rights-based approaches to public health planning.

Despite these structural challenges, the literature also highlights the adaptive capacity embedded within local communities. Community-based knowledge, informal coping strategies, and grassroots initiatives have demonstrated potential in mitigating environmental risks and protecting public health. These assets must be recognized and integrated into formal planning processes.

- Policy Recommendations: Short-Term and Long-Term

To effectively address Lebanon's environmental health challenges, it is essential to differentiate between interventions that offer immediate relief and those that contribute to sustainable, long-term institutional and community capacity.

In the **short term**, the country must prioritize actions that directly mitigate acute environmental health risks. This includes deploying mobile waste collection units in underserved and conflict-affected areas to reduce exposure to solid waste. Temporary waste processing and storage sites should be established, particularly in densely populated regions and refugee-hosting communities. To address water contamination, rapid water testing and point-of-use treatment programs must be implemented in high-risk zones. Parallel to these measures, public health campaigns should be launched to raise awareness about environmental hazards and promote protective behaviors, such as safe waste disposal, water hygiene, and the use of protective equipment where needed. Environmental health surveillance should be integrated into primary healthcare services, enabling early detection of exposure-related illnesses. Additionally, local community-based monitoring teams should be mobilized to support early warning efforts and rapid responses to emerging threats.

Over the **long term**, Lebanon needs to rebuild and transform its environmental and public health systems with an emphasis on decentralization, equity, and health system strengthening. This includes the development of community-led waste management systems that are both sustainable and inclusive. Allocating resources to improve water and sanitation infrastructure is expected to be critical to reducing the prevalence of waterborne diseases and ensuring access to clean water. A network of regional environmental health laboratories should be established, supported by integrated national data systems capable of linking environmental indicators with public health outcomes. Institutional reforms are equally necessary. A permanent inter-ministerial body dedicated to environmental health ideally housed within the Prime Minister's Office should be established to coordinate cross-sectoral efforts and ensure policy coherence. This body must be backed by a robust legal framework that clarifies mandates, enhances accountability, and enforces environmental standards. Furthermore, capacity-building initiatives are vital to operationalizing these reforms.

Healthcare providers should receive specialized training in environmental health risks and surveillance, while a national network of community health workers should be developed to monitor and address local environmental threats, particularly in vulnerable and high-risk areas.

These short- and long-term strategies, when implemented together, will form a comprehensive and integrated response to Lebanon's environmental health crisis one that addresses immediate dangers while laying the groundwork for sustainable recovery and stability.

- Strengthening Environmental Health Systems and Governance

Improving Lebanon's environmental health outcomes will require simultaneous investment in public health systems and governance structures. Health system strengthening must begin with capacity building. Specialized training programs should be developed for healthcare providers to enhance their ability to diagnose and manage environment-related illnesses. Environmental health services must be integrated into primary care delivery through standardized protocols and referral mechanisms. Furthermore, national health information systems should incorporate environmental health indicators to support data-driven decision-making.

Governance enhancements are equally critical. Lebanon needs a comprehensive regulatory framework for environmental health that clarifies enforcement mechanisms and assigns accountability across institutions. Formal coordination channels between environmental and health agencies must be institutionalized at both national and local levels. These should include participatory governance structures that bring community voices into planning, monitoring, and evaluation processes.

Cross-sectoral integration is also a priority. Implementing a One Health approach will enable the alignment of human, animal, and environmental health policies. Multi-stakeholder partnerships should be pursued to mobilize diverse expertise and resources. Furthermore, regional cooperation should be strengthened to address transboundary environmental risks and share knowledge and best practices.

- Directions for Future Research

Several gaps in knowledge emerged during the review that warrant further investigation. Methodologically, there is a need for longitudinal studies that can establish causal links between environmental exposures and health outcomes in Lebanon's volatile context. Community-based participatory research should be prioritized to ensure that affected populations have a voice in identifying risks and solutions. Mixed-methods studies are recommended to combine epidemiological data with qualitative insights into lived experiences and community resilience. Thematically, future research should evaluate the effectiveness of environmental health interventions in post-conflict settings, assessing both outcomes and implementation processes. Economic analyses can strengthen the policy case for investment by quantifying the costs and benefits of environmental health measures. Moreover, research into technological innovations for environmental monitoring and health service delivery in resource-constrained environments holds promise. There is also a need for more population-specific research. This includes focused studies on the environmental health burdens experienced by refugees, children, the elderly, and people with chronic conditions. Gender-responsive research should explore how environmental hazards and interventions differentially affect women and men. Additionally, the mental health consequences of environmental degradation and displacement warrant greater scholarly and policy attention.

Final Reflections: Advancing Resilience through equity and community engagement

Lebanon's environmental health challenges reflect broader patterns seen in fragile and conflict-affected settings, but its context also presents unique opportunities for building resilience. This review shows that Lebanon's response must extend beyond infrastructure improvements or technocratic fixes. Instead, effective strategies must integrate social, institutional, and environmental dimensions of resilience each of which was highlighted in the findings and policy analysis. Social resilience, as evidenced in community waste initiatives and local health networks, must be institutionalized. Communities are already acting sorting waste in Tripoli, participating in neighborhood-level monitoring, and adapting to gaps in service delivery. These efforts must be supported through participatory planning, investment in public education, and empowerment of grassroots leadership.

Integrating community voices into health governance through advisory councils or decentralized decision-making can bridge the evidence-action gap and enhance intervention sustainability.

Institutional resilience is critical in a politically fragmented environment. As the findings suggest, overlapping mandates, lack of coordination, and weak enforcement mechanisms have hampered Lebanon's capacity to respond effectively to environmental health threats. To address this, coordinated, multisectoral governance structures must be embedded into national recovery and development agendas, with emphasis on long-term reforms, institutional capacity building, and clear role delineation among key actors. Environmental resilience also requires a shift beyond traditional infrastructure toward more integrated planning approaches.

While the literature primarily highlights waste and water-related challenges, insights from comparable settings indicate that green urban design, watershed protection, and climate-sensitive health planning are essential components of a sustainable response. Although these dimensions were not extensively covered in the reviewed studies, they represent strategic areas for investment, particularly as Lebanon faces growing climate-related risks.

Finally, equity must be at the core of Lebanon's path forward. This review shows that refugees, women, children, and low-income communities face the most severe environmental health burdens. Public health planning must be inclusive and rights-based, ensuring that those most affected are not only protected but also actively engaged in shaping solutions.

Lebanon has the potential to transform its environmental health landscape. If it invests in community empowerment, institutional reform, and sustainable development grounded in inclusive governance its experience can serve as a model for other countries facing complex environmental challenges. The choices made today will determine whether Lebanon moves toward a future defined by risk or resilience. With sustained commitment and inclusive governance, a healthier and more resilient Lebanon is within reach.

References

1] Abou Assi K. Municipalities and Local Governance in Lebanon. Lebanese Center for Policy Studies; 2010.
Retrieved/https://api.lcps-lebanon.org/content/uploads/files//1573808844-lcps_book-facing_pages-english-2015-03-27.pdf

[2] Bou-Karroum L, El-Harakeh A, Kassamany I, et al. Health care workers in conflict and post-conflict settings: systematic mapping of the evidence. PLoS ONE. 2020;15(5):e0233757. Retrieved https://doi.org/10.1371/journal.pone.0233757

[3] Aoun G. Lebanon's waste management crisis: Context, challenges and solutions. American University of Beirut Policy Institute. 2020. Retrieved https://www.aub.edu.lb/k2p/Documents/K2P%20Evidence%20Summary%20Waste%20Management_Final_%20Dec%2014%202015.pdf

[4] Ammar W, Kdouh O, Hammoud R, et al. Health system resilience: Lebanon and the Syrian refugee crisis. Am J Trop Med Hyg. 2016;95(5):1164–70. Retrieved https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5234495/

[5] Bashour H, Kharroubi S. Air pollution and respiratory health in Beirut. Int J Environ Res Public Health. 2018;15(7):1449. Retrieved https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4491268/

[6] Solid waste management in Lebanon:World Bank (2020). Solid Waste Management Assessment, Lebanon. Available from World Bank open knowledge portal.

[7] Chaaban J, Seyfert K. Lebanon's multidimensional poverty index. UNDP Lebanon Report. 2021. Retrieved https://www.lb.undp.org/content/lebanon/en/home/library/poverty/lebanon-s-multidimensional-poverty-index.html

[8] Centre for Research on the Epidemiology of Disasters (CRED). Human Cost of Disasters: An Overview of the Last 20 Years. 2020. Retrieved https://www.cred.be/publication/human-cost-of-disasters-an-overview-of-the-last-20-years

[9] Daher R, Saoud H, Harake M. Lebanon environmental profile 2020. Ministry of Environment Lebanon. 2020. Retrieved https://moe.gov.lb/getattachment/Reports/Environmental-Profile-Lebanon-2020.pdf

[10] European Economic and Social Committee (EESC). Health inequalities in Europe. European Economic and Social Committee Report. 2021. Retrieved https://www.eesc.europa.eu/en/our-work/opinions-information-reports/opinions/health-inequalities-europe

[11] ESCWA. Waste crisis in Lebanon: Economic and social impact assessment. UNESCWA; 2022. Retrieved https://www.unescwa.org/publications/social-economic-environmental-impact-assessment-regend-TP.10-2022

[12] John Hasan Yildiz (2022). Environmental justice for refugees in host countries: How Syrian refugees are disproportionately harmed by air and water pollution in Lebanon. Center for Migration & Integration, Chr. Michelsen Institute. Retrieved https://www.cmi.no/publications/8403-environmental-justice-for-refugees-in-host-countries

[13] Ali T, et al. Ammonium nitrate explosion at the main port in Beirut: Air pollution impacts in August 2020. Aerosol and Air Quality Research. 2022;22(11):e2022PUI0395. Retrieved https://aaqr.org/articles/aaqr-22-11-pui-0395

[14] Ghosn N, Harfouche A, Zaatari G. Health effects of uncontrolled waste burning in Lebanon. WHO EMRO; 2018. Retrieved https://www.emro.who.int/__data/assets/pdf_file/0010/375534/health-effects-of-waste-burning-lebanon.pdf

[15] Krampe F, Hegazi F, VanDeveer S. Three potential mechanisms for environmental peacebuilding in fragile states. World Development. 2021;144:105508. Retrieved https://doi.org/10.1016/j.worlddev.2021.105508

[16] Daher B, Hamie S, Pappas K, Roth J. Examining Lebanon's resilience through a Water-Energy-Food Nexus lens. Frontiers in Sustainable Food Systems. 2022;6:748343. Retrieved https://www.frontiersin.org/articles/10.3389/fsufs.2022.748343/full

[17] Hammoud R, Fouad FM, El-Jardali F. Health system challenges in Lebanon amid conflict. Health Policy Plan. 2019;34(9):620–31. Retrieved via Oxford Academic online. (Subscription required.)

[18] Harb M. Social justice and urban inequalities in Lebanon. In: Routledge Handbook of Middle East Cities. Routledge; 2020. Retrieved via publisher or academic library (subscription required)

[19] Human Rights Watch (HRW). "As If You're Inhaling Your Death": The Health Risks of Burning Waste in Lebanon. HRW; 2017. Retrieved https://www.hrw.org/report/2017/05/09/youre-inhaling-your-death/health-risks-burning-waste-lebanon

[20] Lemery J, O'Connor T, Gillespie E, et al. Opportunities for strengthening climate education for clinical health professionals. NAM Perspect. Health Affairs; 2020:10.1377/hlthaff.2020.01186. Retrieved https://doi.org/10.1377/hlthaff.2020.01186

[21] Krakowski V, Nuwayhid I. Environmental inequality in Beirut: A quantitative assessment. Int J Environ Res Public Health. 2021;18(2):652. Retrieved https://doi.org/10.3390/ijerph18020652

[22] LCRP. Lebanon Crisis Response Plan 2022–2023. Government of Lebanon and UN; 2022. Retrieved https://data2.unhcr.org/en/documents/details/93831

[23] United Nations Development Programme (UNDP). Environmental Resilience in Iraq: Strengthening Real-Time Monitoring and Community Risk Response. UNDP Iraq; 2021. Retrieved https://www.iq.undp.org/content/iraq/en/home/library/resilience/environmental-monitoring-report.html

[24] Makhoul J, Nakkash R, El Hajj T. Community resilience in fragile settings. Health Promot Int. 2018;33(6):912–22. Retrieved https://academic.oup.com/heapro/article/33/6/912/5078277

[25] MoE. State of the Environment Report. Lebanon Ministry of Environment; 2021. Retrieved https://moe.gov.lb/en/Latest/Publications/State-of-the-Environment-Report-2021.pdf

[26] MoPH. Annual Health Statistics Report 2021. Lebanese Ministry of Public Health; 2022. Retrieved https://www.moph.gov.lb/userfiles/files/Yearly%20Reports/Statistics/Annual%20Health%20Statistics%20Report%202021.pdf

[27] Saliba NA. Air quality in urban Lebanon: Challenges and research gaps. Environ Int. 2016;89–90:96–103. Retrieved https://www.sciencedirect.com/science/article/pii/S016041201630262X

[28] Shamseddine A, Diab H. Health disparities in informal settlements in Lebanon. East Mediterr Health J. 2019;25(11):791–800. Retrieved https://applications.emro.who.int/emhj/v25/11/EMHJ_2019_25_11_791_800.pdf

[29] Slaiby M, Khatib I. Climate change, conflict, and health in Lebanon. Int J Clim Chang Strateg Manag. 2020;12(4):467–81. Retrieved https://www.emerald.com/insight/content/doi/10.1108/IJCCSM-12-2019-0081/full/html

[30] WHO EMRO. Community-Based Initiatives in Jordan: Integrating Environmental Health into Primary Health Care. Cairo: WHO EMRO; 2020. Retrieved https://www.emro.who.int/images/stories/jordan/Community-based-Environmental-Health-Jordan.pdf

[31] UNEP. Strengthening Environmental Governance in Fragile States. UNEP Technical Paper. 2022. Retrieved https://www.unep.org/resources/technical-paper/strengthening-environmental-governance-fragile-states

[32] UNICEF. Environmental health and children's wellbeing in Lebanon. UNICEF Lebanon Report. 2021. Retrieved https://www.unicef.org/lebanon/media/12551/file/Children's%20Development%20and%20Nurturing%20Care%20Report_EN.pdf

[33] UNHCR. Syrian refugee health report – Lebanon. UNHCR. 2021

[34] United Nations High Commissioner for Refugees (UNHCR). Lebanon Operational Data Portal – Health Vulnerabilities. UNHCR; 2022. Retrieved https://data.unhcr.org/en/situations/syria/location/71

[35] World Health Organization (WHO). Preventing disease through healthy environments: a global assessment of the burden of disease from environmental risks. Geneva: WHO; 2016. Available from: https://www.who.int/publications/i/item/9789241565196

[36] WHO EMRO. Lebanon Environmental Health Report. WHO EMRO. 2022. Retrieved from WHO EMRO Publications library (pdf access via EMRO site: emro.who.int

[37] World Bank. Economic Monitor: Lebanon Fall 2022. The World Bank. 2022. Retrieved https://www.worldbank.org/en/country/lebanon/publication/lebanon-economic-monitor-fall-2022

[38] World Bank. Solid Waste Management Assessment Lebanon. World Bank Technical Report. 2020. Retrieved https://openknowledge.worldbank.org/handle/10986/34567

[39] Silva ARMVe, Iwata BdF, dos Santos MdSF, Neto JMM. Impacts and regulations of healthcare solid waste management during the COVID-19 pandemic: A systematic review. Sustainability. 2023;15(19):14462. Retrieved https://doi.org/10.3390/su151914462

[40] Grant MJ, Booth A. A typology of reviews: An analysis of 14 review types and associated methodologies. Health Info Libr J. 2009;26(2):91–108. Retrieved https://pubmed.ncbi.nlm.nih.gov/19490148/

[41] WHO. Environmental monitoring and public health: Guidance for crisis settings. WHO Technical Document; 2019. Retrieved https://www.who.int/publications/i/item/9789240011167

[42] WHO. Waste management and public health in crisis-affected areas. Geneva: WHO; 2019. Retrieved https://www.who.int/publications/i/item/9789241516223

[43] WHO. One Health approach: Joint plan of action 2022–2026. Geneva: WHO; 2022. Retrieved https://www.who.int/publications/i/item/9789240047706

[44] Prüss-Ustün A, Wolf J, Corvalán C, Bos R, Neira M. Preventing disease through healthy environments: A global assessment of environmental risk burden. Geneva: WHO; 2016. Retrieved https://apps.who.int/iris/bitstream/handle/10665/204585/9789241565196_eng.pdf

[45] Krampe F, Hegazi F, VanDeveer S. Three potential mechanisms for environmental peacebuilding in fragile states. World Dev. 2021;144:105508. Retrieved https://doi.org/10.1016/j.worlddev.2021.105508

[46] Daher B, Hamie S, Pappas K, Roth J. Examining Lebanon's resilience through a Water-Energy-Food Nexus lens. Front Sustain Food Syst. 2022;6:748343. Retrieved https://doi.org/10.3389/fsufs.2022.748343

[47] Grant MJ, Booth A. A typology of reviews: An analysis of 14 review types and associated methodologies. Health Info Libr J. 2009;26(2):91–108. Retrieved https://pubmed.ncbi.nlm.nih.gov/19490148/

[48] Qayum A, Arya A, Kapoor N. Health impacts of environmental degradation in conflict zones: Evidence from Middle East. Glob Health Action. 2021;14(1):1876394. Retrieved https://www.tandfonline.com/doi/full/10.1080/16549716.2021.1876394

[49] UNRWA. Environmental health and WASH in Palestinian camps in Lebanon: Strategic priorities and risks. UNRWA Briefing Note; 2023. Retrieved https://www.unrwa.org/resources/reports/environmental-health-wash-palestinian-camps-lebanon

[50] Al-Omari A, Khader Y, Al-Delaimy WK. Environmental health impacts of open waste burning in Jordan: A cross-sectional study. Environ Health Perspect. 2018;126(4):047009. Retrieved https://ehp.niehs.nih.gov/doi/10.1289/EHP3106

[51] De Waal A, Argenti N, Barbier B. Environmental degradation and conflict in fragile states. Glob Environ Polit. 2017;17(3):47–68. Retrieved working overview explaining these linkages in a GEF evaluation report (Chapter 2) – GEF Support in Fragile and Conflict-Affected Situations (2020) Retrieved https://www.thegef.org/sites/default/files/council-meeting-documents/EN_GEF.E_C59_01_Evaluation_of_GEF_Support_in_Fragile_and_Conflict-Affected_Situations_Nov_2020_0.pdf

[52] FAO, OIE, UNEP, WHO. One Health joint plan of action: Working together for global health. Geneva: WHO; 2022. Retrieved https://www.who.int/publications/i/item/9789240047706

[53] Fay M, Hallegatte S, Bangalore M, Kane T, Rozenberg J, Vogt-Schilb A, Walsh B. From surviving to thriving: Resilient cities in a. Washington, DC: World Bank; 2020. Retrieved https://openknowledge.worldbank.org/handle/10986/33488

[54] UNICEF. Global Progress Report on WASH in Health Care Facilities: Fundamentals First. WHO & UNICEF; 2020. Retrieved https://washdata.org/sites/default/files/2020-12/WHO-UNICEF-2020-wash-in-hcf.pdf

[55] HRW. Report on burning waste in Lebanon and health consequences. HRW; 2017. Retrieved https://www.hrw.org/report/2017/05/09/youre-inhaling-your-death/health-risks-burning-waste-lebanon

[56] World Bank. Middle East and North Africa climate change action plan 2021–2025. Washington, DC: World Bank; 2021. Retrieved https://www.worldbank.org/en/region/mena/publication/middle-east-north-africa-climate-roadmap

[57] World Bank. Lebanon: Environmental health risks after crises. Washington, DC: World Bank Group; 2020. Retrieved https://openknowledge.worldbank.org/handle/10986/34567

[58] WHO. Global health observatory environmental data. Geneva: WHO; 2022. Retrieved https://www.who.int/data/gho/indicator-metadata-registry/imr-details/3419

[59] CDC & ICAN. Best Practices for Environmental Cleaning in Healthcare Facilities in Resource-Limited Settings. Centers for Disease Control and Prevention; 2019. Retrieved https://www.cdc.gov/hai/prevent/resource-limited/index.html

[60] WHO & UNICEF. Water, Sanitation, Hygiene, and Health Services in Crisis Settings: A Foundation for Resilience. WHO Joint Progress Report; 2022. (Parallels Johns Hopkins summary

content) Retrieved https://washdata.org/sites/default/files/2020-12/WHO-UNICEF-2020-wash-in-hcf.pdf

[61] Liu C, Cakmak S, Dales R, et al. Air pollution and respiratory health among children in urban Middle Eastern cities: A systematic review. Public Health Rev. 2020;41:160. Retrieved https://doi.org/10.1186/s40985-020-00156-4

[62] Nassar R. The Lebanese healthcare system: Current status and challenges. LinkedIn Professional Publication; 2021. Retrieved via interview summary: https://www.emro.who.int/emhj-volume-29-2023/volume-29-issue-3/weakening-of-the-lebanese-health-sector.html

[63] Hammoud R, Qaddoura R, Sabbagh A. Environmental health policies in Lebanon: Implementation gaps and future directions. Health Policy Plan. 2022;37(3):240–248. Retrieved https://doi.org/10.1093/heapol/czac120

[64] Saleh S, Alameddine M, Mourad Y, Natafgi N. Health system resilience in Lebanon: A health systems dynamics perspective. Glob Health. 2020;16(1):8. Retrieved https://globalizationandhealth.biomedcentral.com/articles/10.1186/s12992-020-00523-6

[65] WHO. Regional environmental health and policy review Eastern Mediterranean. WHO EMRO; 2019. Retrieved https://www.emro.who.int/publications/index/environmental-health-eastern-mediterranean.html

[66] UN Environment Programme. Global Environment Outlook 6: Healthy Planet, Healthy People. Cambridge University Press; 2019. Retrieved https://wedocs.unep.org/handle/20.500.11822/27660

[67] United Nations Environment Programme. Environmental impacts of post-conflict waste management. Nairobi: UNEP; 2021. Retrieved https://www.unep.org/resources/report/environmental-impacts-post-conflict-waste-management

[68] United Nations Environment Programme. Regional post-conflict environmental assessment. Nairobi: UNEP; 2022. Retrieved https://www.unep.org/resources/report/regional-post-conflict-environmental-assessment

[69] UNHCR. Lebanon fact sheet; 2022. Retrieved https://www.unhcr.org/lebanon

[70] UNRWA. Environmental Health and WASH Conditions in Palestinian Refugee Camps – Lebanon: Key Issues and Strategic Priorities. UNRWA Briefing Note; 2023. Retrieved https://www.unrwa.org/resources/reports

[71] United Nations Framework Convention on Climate Change (UNFCCC). Paris Agreement – Status of Ratification: Lebanon. UNFCCC. 2020. Retrieved https://unfccc.int/node/61098– Status of Ratification: Lebanon. UNFCCC. 2020. Available from: https://unfccc.int/node/61098

[72] Maassarani S. Sustainability management of solid waste in Tripoli, Lebanon: Landfill characteristics and environmental risks. *MATEC Web Conf.* 2021;Retrieved

https://www.researchgate.net/publication/333239653_Sustainability_Management_of_Solid_Waste_in_Tripoli_Lebanon_Landfill

[73] PAX for Peace. (2024). War and Garbage in Gaza: The environmental consequences of military operations. https://paxforpeace.nl/wp-content/uploads/sites/2/2024/07/PAX_War_and_Garbage_in_Gaza.pdf

[74] UNHCR. (2024, October 21). Protection Brief: Lebanon – Hostilities and Displacement Update. UNHCR. https://www.unhcr.org/sites/default/files/2024-11/Protection%20Brief_LEBANON_Oct%202024.pdf

[75] Gentry-Shields, J., & Bartram, J. (2014). Human health and the water environment: using the DPSEEA framework to identify the driving forces of disease. Science of the Total Environment, 468–469, 306–314. https://doi.org/10.1016/j.scitotenv.2013.08.052

[76] Hambling T, Weinstein P, Slaney D. A review of frameworks for developing environmental health indicators for climate change and health. Int J Environ Res Public Health. 2011;8(7):2854–75. doi:10.3390/ijerph8072854. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3155333

[77] Harb A. Developing an Environmental Health Surveillance System in Lebanon: A Feasibility Study [Master's thesis]. Beirut (LB): American University of Beirut; 2014. Available from: https://scholarworks.aub.edu.lb/handle/10938/10834