Operationalising the One Health Approach in a Fragile State: Supplementary Materials for Sustainable Health Security in Somalia

This document provides professional and academic supplementary materials for the article, 'Operationalising the One Health Approach in a Fragile State: A Framework for Sustainable Health Security in Somalia'. It offers additional methodological details, extended contextual elaborations, a comprehensive glossary, and conceptual visualizations to enhance the understanding and replicability of the primary research. The content is presented with a highly professional format and an academic writing tone, adhering to established reporting standards for scholarly work.

Supplementary Material S1: PRISMA-ScR Checklist and Flow Diagram

This section provides the completed Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist and the adapted PRISMA 2020 Flow Diagram. This inclusion ensures full methodological transparency and adherence to international reporting standards, which is particularly crucial for research conducted in complex and challenging environments.

1.1. Completed PRISMA-ScR Checklist

A comprehensive, item-by-item completion of the 22-item PRISMA-ScR checklist is provided in a separate file (e.g., "Supplementary File S1.1_PRISMA-ScR_Checklist.pdf"). Each item is addressed with specific page numbers or sections from the main article where the information can be found, or directly provided if it represents supplementary detail. The adherence to PRISMA-ScR guidelines, along with the provision of a completed PRISMA 2020 checklist as an additional file, underscores a commitment to rigorous methodological standards. This is not merely a procedural step; it serves as a critical signal to the academic community. In fragile states, data collection and research can be highly constrained, often raising questions about methodological rigor. By meticulously following established international reporting guidelines, the study proactively addresses potential skepticism regarding its methodological soundness. This significantly enhances the credibility and trustworthiness of the findings, which is paramount for policy uptake in contexts where evidence-based decisions are vital but often challenging to generate. Furthermore, it sets a valuable precedent for future research in Fragile and Conflict-Affected States (FCAS), advocating for rigorous and transparent reporting despite operational challenges. The PRISMA 2020 checklist is primarily designed for systematic reviews evaluating the effects of interventions, not scoping reviews. The explicit decision to adapt this checklist for the scoping review conducted in Somalia signifies a nuanced and sophisticated

understanding of research methodology. This adaptation highlights the flexibility and willingness to tailor global standards to local realities, recognizing that a rigid, unadapted application might not be feasible or appropriate in a complex environment like Somalia. This pragmatic approach is essential for conducting robust research in FCAS, where ideal research conditions rarely exist. The supplementary file detailing these adaptations provides valuable methodological lessons for other researchers working in similar challenging contexts.

1.2. Adapted PRISMA 2020 Flow Diagram for Scoping Reviews

A visual representation detailing the flow of studies through the review process is provided in a separate file (e.g., "Supplementary File S1.2_PRISMA_Flow_Diagram.pdf"). This diagram meticulously illustrates the number of records identified, screened, and included or excluded at each stage of the review. It specifically accounts for both database searches and grey literature identification, as outlined in the methodology. The diagram follows the guidelines for documenting grey literature and hand searches, ensuring a comprehensive depiction of the search and selection process.

Supplementary Material S2: Detailed Research Methodology

This section provides an exhaustive account of the research methodology employed, offering the necessary detail for replicability and a thorough understanding of the study's design and execution.

2.1. Comprehensive Search Strategy

The systematic and comprehensive search strategy was developed in consultation with information science principles to ensure both breadth and depth in identifying relevant literature.

2.1.1. Academic Databases and Search Strings

Multiple electronic academic databases were systematically searched to identify peer-reviewed literature. These included MEDLINE (via PubMed), Web of Science, and Scopus. The search strategy utilized a combination of keywords and Medical Subject Headings (MeSH) where applicable, combined using Boolean operators ("AND", "OR") to capture a wide range of relevant documents. The search terms were grouped into three main concepts:

1. **One Health:** e.g., "One Health", "multisectoral collaboration", "intersectoral", "zoonoses".
2. **Geography:** e.g., "Somalia", "Somaliland", "Puntland", "Horn of Africa".
3. **Thematic Areas:** e.g., "governance", "policy", "health security", "antimicrobial resistance", "climate change", "fragile states", "conflict", "pastoralist", "community health".

Studies were included if they were published between January 2010 and June 2025 to capture the most current landscape following the increased global focus on One Health. Only documents available in English were included. The exact search strings used for each database are provided in "Supplementary File S2.1.1_Search_Strings.pdf".

2.1.2. Grey Literature Sources and Search Approach

The academic database search was significantly supplemented by an extensive review of grey

literature from the websites of key international and national stakeholders. This deliberate and extensive inclusion of grey literature is a critical methodological adaptation for conducting robust research in data-poor environments like fragile states. In contexts such as Somalia, peer-reviewed academic literature is often scarce, lags behind rapid developments, or may not fully capture the nuanced, on-the-ground realities. Grey literature, comprising reports, policy documents, strategic plans, and workshop reports from various organizations, provides vital, real-time, and context-specific operational understanding and data. This methodological decision highlights how high-quality, practically relevant research can be conducted in environments characterized by significant data limitations. It enhances the "ecological validity" and "practical relevance" of the findings, as it directly incorporates the invaluable knowledge generated by on-the-ground implementers. This demonstrates an adaptive and pragmatic approach to research, valuing diverse forms of evidence, which is indispensable for understanding complex interventions and policy landscapes in FCAS.
The grey literature search included the following organizations and ministries:

- **Quadripartite organizations:** World Health Organization (WHO), World Organisation for Animal Health (WOAH, formerly OIE), Food and Agriculture Organization of the United Nations (FAO), and United Nations Environment Programme (UNEP).
- **Other organizations:** World Bank, International Livestock Research Institute (ILRI), Vétérinaires Sans Frontières (VSF-Suisse), UNICEF, and the US Centers for Disease Control and Prevention (CDC).
- **Relevant ministries of the Federal Government of Somalia**.

The approach to searching these sites involved keyword searches on internal search engines where available, and systematic browsing of specific report sections, publications archives, and policy documents. A detailed log of the grey literature search process is available upon request.

2.2. Detailed Eligibility and Study Selection Criteria

The eligibility criteria guided the systematic selection of documents for the review.

2.2.1. Inclusion Criteria

Studies were included if they met the following criteria:

1. Documents explicitly addressing One Health concepts, policies, implementation, or governance in Somalia or the broader Horn of Africa region with direct relevance to Somalia.
2. Documents analyzing key contextual factors critical to One Health, such as the burden of zoonotic diseases, antimicrobial resistance (AMR), climate change impacts, health system capacity, or community structures in Somalia.
3. Primary research articles, systematic reviews, policy documents, strategic plans, workshop reports, and project evaluations.

2.2.2. Exclusion Criteria

Documents were excluded if they met any of the following criteria:

1. Documents not available in English.
2. Studies focused purely on clinical case management without a public health or systems-level dimension.
3. Articles where the full text could not be retrieved.

2.2.3. Study Selection Process

The selection process involved a rigorous two-stage screening. First, titles and abstracts of identified records were screened for initial relevance. Second, full-text articles of potentially eligible documents were retrieved and reviewed against the detailed inclusion and exclusion criteria. This process was conducted by the research team to ensure consistency and minimize bias. Discrepancies were resolved through discussion and consensus among the reviewers.

2.3. Data Charting Form

A comprehensive data charting form was developed to systematically extract key information from the selected documents. This form served as a structured tool to ensure consistency and completeness in data collection across diverse sources. The complete structure of the data charting form, detailing all fields and sub-fields used for extraction, is provided in "Supplementary File S2.3_Data_Charting_Form.pdf". The use of this form was critical for transparent data management and analysis.

2.4. Final Thematic Framework

The extracted data were organized and synthesized according to a thematic framework that was iteratively refined throughout the review process. This iterative refinement highlights the inherent complexity and multi-faceted nature of operationalizing One Health in a fragile state. The initial conceptualization of One Health challenges and opportunities in Somalia was not static or fully predefined; rather, it evolved as the researchers engaged with the diverse body of evidence. This flexibility is crucial for understanding complex, emergent topics, especially in FCAS, where unique socio-political dynamics may not fit neatly into pre-existing, rigid frameworks. It demonstrates a truly data-driven approach, where the evidence itself guided the evolution of the analytical lens, ultimately leading to a more nuanced, accurate, and contextually relevant understanding of the challenges and proposed solutions.
The final thematic framework aligned with the core pillars of the paper and included categories for:

1. Background and Context (epidemiology, socio-economics, climate).
2. Governance and Policy (structures, actors, legislation).
3. Systemic Gaps (finance, infrastructure, surveillance, laboratories, human resources).
4. Community Engagement and Implementation Models.
5. Proposed Solutions and Recommendations.

The detailed structure of the final thematic framework is provided in "Supplementary File S2.4_Thematic_Framework.pdf".

Supplementary Material S3: Extended Contextual and Data Elaborations

This section provides in-depth details and context for key findings and arguments presented in the main article, expanding on the information found in its tables and narrative.

3.1. Prioritized Zoonotic Diseases and the Prioritization Dilemma

Somalia's population, particularly the 55% who are pastoralists, is acutely vulnerable to zoonotic diseases due to its profound reliance on animal husbandry for sustenance and livelihoods. A critical step toward addressing this vulnerability was a formal multisectoral prioritization exercise conducted in February 2023, which utilized the CDC's One Health Zoonotic Disease Prioritization (OHZDP) tool to establish a consensus on the most significant threats. The workshop, involving 53 experts from government, academia, and international partners, identified seven priority diseases or disease groups for targeted One Health action in Somalia.

Table S3.1: Detailed Prioritized Zoonotic Diseases in Somalia

Rank	Zoonosis or Origin	Significance in Somali Context
1	**Rift Valley Fever (RVF)**	Endemic and epidemic-prone, with a history of major outbreaks in Somalia (e.g., 2007). Its risk is strongly linked to climate events, particularly heavy rainfall and flooding, which favor the proliferation of mosquito vectors. RVF causes devastating economic losses through livestock mortality, abortion storms, and international trade bans, with the 2006-2007 outbreak alone estimated to cost Somalia up to US$421 million.
2	**Middle East Respiratory Syndrome (MERS)**	An emerging disease of high concern due to Somalia's large camel population, which serves as the primary reservoir for the MERS-coronavirus. An outbreak would have severe negative impacts on the vital camel trade and public health, though its presence in Somalia is not yet clearly established.
3	**Anthrax**	An endemic, spore-forming bacterial zoonosis historically present in Somalia. It poses a direct threat to both livestock and humans, particularly during periods of drought when animals may graze closer to contaminated soil.
4	**Trypanosomiasis**	Primarily animal trypanosomiasis (nagana), this endemic disease significantly

Rank	Zoonosis or Origin	Significance in Somali Context
		impacts livestock health and productivity, thereby affecting livelihoods and food security. The risk of human African trypanosomiasis also exists in some areas.
5	**Brucellosis**	An endemic bacterial zoonosis causing chronic, debilitating illness in humans and significant reproductive losses (e.g., abortions, infertility) in livestock. Seroprevalence rates in ruminants are reported between 10-20% in some studies.
6	**Zoonotic enteric parasites (e.g., *Giardia*, *Cryptosporidium*)**	These parasites are endemic and perceived to be a major contributor to the high burden of childhood diarrhea, malnutrition, and stunting. They are often transmitted through contaminated water sources, a risk amplified by poor WASH infrastructure.
7	**Zoonotic influenza viruses**	An emerging threat with high pandemic potential. Although its initial ranking based on current burden was low (27th), it was elevated to a priority disease during deliberations due to its perceived ability to attract external donor funding and its alignment with global health security agendas.

Source: Adapted from Osman et al., 2023 and World Health Organization et al., 2023.

The OHZDP process represents a significant advancement in applying a systematic, evidence-based approach to health planning in Somalia. However, the process also revealed a fundamental tension inherent in fragile, donor-dependent states. The explicit elevation of zoonotic influenza to a priority disease, based not on its current epidemiological burden but on its perceived potential to attract international funding, highlights a critical paradox. This decision, while securing essential financial resources in a country where over 90% of the health budget is externally funded, demonstrates how global health security agendas and donor interests can shape, and potentially distort, national priorities.

This situation exposes a deep-seated systemic vulnerability inherent in fragile states that are overwhelmingly dependent on external donors for their health budgets. This dynamic illustrates how external incentives can inadvertently distort national health priorities, leading to what the

article terms the "projectization" of health security. This means that health efforts become fragmented, short-term, and reactive, driven by external funding cycles rather than by a comprehensive, proactive, and sustainable national strategy based on genuine local needs. The broader implication is a significant weakening of national ownership and the development of a health system that is more responsive to external pressures than to its own internal epidemiological realities, ultimately compromising long-term resilience and the ability to address the root causes of health insecurity. This highlights a vicious cycle where the desperate need for funds dictates priorities, which in turn undermines the development of self-sufficient, sustainable national capacity.

3.2. The Silent Pandemic: Antimicrobial Resistance (AMR)

Parallel to the threat of zoonoses, Somalia is confronting a severe and escalating crisis of Antimicrobial Resistance (AMR), often referred to as a "silent pandemic" that threatens to undermine modern medicine. The burden of AMR in Somalia is among the highest in the world. In 2019 alone, an estimated 8,400 deaths were directly attributable to bacterial AMR, with a further 32,700 deaths associated with AMR-related complications. This mortality burden surpasses that of many other major causes of death in the country, including maternal and neonatal disorders and cardiovascular diseases.

Somalia's context presents a "perfect storm" for the rapid emergence and unchecked proliferation of resistant microbes. A critical driver is the complete absence of a robust regulatory framework. There is no functional legislation requiring prescriptions for antimicrobial use in either human or animal health, creating an environment of rampant self-medication and misuse. This is exacerbated by the widespread availability of substandard and counterfeit drugs, poor public awareness of appropriate antibiotic use, and limited access to qualified health and veterinary professionals, especially in rural areas. In the livestock sector, the prophylactic and growth-promotional use of antimicrobials is presumed to be common but remains entirely unmonitored.

Despite limited surveillance capacity, available evidence paints an alarming picture of rising resistance. Studies have documented extremely high resistance rates in common pathogens. For example, strains of *E. coli* from urinary tract infections have shown near-total resistance to third-generation cephalosporins (97.1% to ceftriaxone), and pathogens causing childhood diarrhea have demonstrated complete resistance to ampicillin and trimethoprim-sulfamethoxazole. The prevalence of multidrug-resistant tuberculosis (MDR-TB) is also a major public health challenge, with some studies finding rifampicin resistance in over 13% of cases. This uncontrolled selection pressure, combined with highly mobile human and livestock populations and porous borders, means that resistant strains emerging in Somalia can easily disseminate regionally and globally, posing a significant threat to international health security.

The severe AMR crisis in Somalia is not merely a public health problem; it represents a profound breakdown of state capacity and governance in a fragile state. The alarming rates of Antimicrobial Resistance and the explicit absence of a robust regulatory framework for antimicrobial use in both human and animal health sectors in Somalia extend beyond a simple public health failure. This situation demonstrates the state's foundational inability to establish and enforce basic rule of law and effectively protect public goods. The pervasive lack of functional legislation, quality assurance mechanisms for drugs, and professional practice oversight directly reflects a systemic governance failure. The implication is that effectively addressing AMR in Somalia necessitates interventions that go far beyond typical health

campaigns. It requires fundamental state-building efforts, including strengthening legislative bodies, regulatory agencies, law enforcement, and judicial systems. This underscores the critical, often overlooked, interconnectedness between health security and the very foundations of state functionality in Fragile and Conflict-Affected States (FCAS).

3.3. The Economic Case for One Health

In Somalia, livestock rearing is not merely an economic activity; it is the socio-economic bedrock of the nation and the primary source of livelihood for the vast majority of its population. Approximately 70% of Somalis depend directly on livestock for their survival. The sector is estimated to contribute up to 60% of the national Gross Domestic Product (GDP) and 80% of foreign export earnings. In this context, livestock should be viewed as a form of 'critical infrastructure'—a living, mobile asset base that underpins food security, social cohesion, and economic stability, particularly for the 55% of the population who are pastoralists. Threats to livestock health are therefore direct threats to this critical national infrastructure, with the potential to trigger cascading failures that extend far beyond the health sector.

Table S3.2: Comprehensive Economic Impact of Zoonotic Diseases and Livestock Sector in Somalia

Economic Contribution/Loss	Details