IDOS DISCUSSION PAPER 34/2025

Mitigating Anti-Microbial Resistance in the Environment

A One Health Governance Analysis in Kenya

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Bonn 2025

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The German Institute of Development and Sustainability (IDOS) is institutionally financed by the Federal Ministry for Economic Cooperation and Development (BMZ), based on a resolution of the German Bundestag, and the state of North Rhine-Westphalia (NRW) as a member of the Johannes-Rau-Forschungsgemeinschaft (JRF).

Suggested citation:
Srigiri, S. R., & Buliva, M. (2025). *Mitigating anti-microbial resistance in the environment: A One Health governance analysis in Kenya* (IDOS Discussion Paper 34/2025). IDOS. https://doi.org/10.23661/idp34.2025

IDOS Discussion Paper / German Institute of Development and Sustainability (IDOS) gGmbH
ISSN 2751-4439 (Print)
ISSN 2751-4447 (Online)
ISBN 978-3-96021-280-5 (Print)
DOI: https://doi.org/10.23661/idp34.2025

Tulpenfeld 6, 53113 Bonn
Email: publications@idos-research.de
https://www.idos-research.de

Printed on eco-friendly, certified paper.

MEMBER OF Johannes-Rau-Forschungsgemeinschaft

Acknowledgements

This study was conducted within the project “Fostering resilience through health and social protection in times of multiple crises”, financed by the German Federal Ministry for Economic Cooperation and Development (BMZ). The study design, data collection, and analysis were undertaken by Dr Srinivasa Srigiri (IDOS) and Dr Morris Buliva (independent researcher and consultant), with able field assistance from Ms Jane Nyambura during expert interviews conducted in 2023 and 2024.

We are deeply grateful to the Government of Kenya, particularly the National Antimicrobial Stewardship Interagency Committee (NASIC) Secretariat, for facilitating access to key stakeholders and providing essential institutional support for this research. We are deeply grateful to numerous experts in Kenya and Germany whose support made this study possible. We extend special thanks to Dr John Mumbo (NEMA) for his indispensable guidance in understanding AMR governance processes and key actors in Kenya’s environmental sector. We are equally grateful to Dr Kenneth K’Oreje (Water Resources Authority) for his valuable insights into water quality governance and environmental surveillance dimensions of AMR. Dr Jane Lwoyero (WOAH) provided crucial assistance through a highly informative meeting and help in identifying key stakeholders across sectors. Meetings and correspondence with the CGIAR AMR Hub at ILRI, led by Dr Arshnee Moodley, provided invaluable insights into the state of AMR and One Health initiatives in Kenya and the region. Above all, we thank the experts from national, county, and facility levels across sectors who generously shared their time, knowledge, and perspectives through detailed and patient responses to our inquiries.

At IDOS, we thank Dr Christoph Strupat, Dr Jean Carlo Rodríguez de Francisco and Dr Tim Möschl for their critical reviews and constructive suggestions that substantially improved this discussion paper. We also acknowledge the valuable guidance of Dr Ines Dombrowsky and Dr Saravanan Subramanian during the early stages of this research.

Abstract

Antimicrobial resistance (AMR) poses a critical threat to global health, with environmental transmission pathways – pharmaceutical waste, wastewater effluents, agricultural runoff – increasingly recognised as significant yet inadequately governed. Despite international calls for One Health approaches integrating human, animal and environmental sectors, coordination across these domains remains weak, particularly for environmental dimensions. This paper examines why environmental integration lags in Kenya's AMR governance, despite sophisticated formal architecture that includes national and county coordination platforms (NASIC, CASICs), technical working groups and the One Health AMR Surveillance System (OHAMRS). We investigate two research questions: (i) What are the enablers and barriers to effective governance of interlinkages among human health, animal health and environmental sectors in mitigating AMR? (ii) What are the options for effectively integrating the environmental dimension into AMR governance?

Drawing on polycentric governance theory, the Institutional Analysis and Development (IAD) framework and the concept of Networks of Adjacent Action Situations (NAAS), we analyse how authority, information and resources shape interactions among overlapping decision centres across constitutional, collective-choice and operational levels. Through 12 semi-structured interviews with government officials, fisheries officers and environmental regulators, supplemented by policy document analysis, we map six action situations spanning planning, resource allocation, surveillance, stewardship, wastewater treatment and regulation.

Findings reveal that constitutional-choice rules create formal overlaps intended to foster coordination, yet systematic asymmetries in authority, information and resources perpetuate the marginalisation of environmental issues. Boundary and position rules concentrate agenda-setting in health sectors; information rules exclude AMR parameters from environmental permits and inspections; payoff rules reward clinical outputs while environmental investments compete with higher priorities; and scope rules omit environmental accountability targets. These rule configurations attenuate feedback loops between environmental action situations and upstream planning, maintaining system stability but at sub-optimal performance for One Health objectives. We identify rule-focused interventions – mandating environmental representation with voting authority, embedding AMR parameters in regulatory instruments, institutionalising joint inspection protocols, ring-fencing environmental budgets, and establishing explicit environmental targets – that would realign coordination toward genuine environmental integration.

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Abbreviations

AIR	authority-information-resources
AMR	anti-microbial resistance
BAT	best available technologies
BEP	best environmental practice
BOD	biological oxygen demand
BMU	beach-management unit
CASIC	County Antimicrobial Stewardship Interagency Committee
COD	chemical oxygen demand
DVS	Directorate of Veterinary Services
EIA	environmental impact assessments
EMCA	Environmental Management and Coordination Act
GDP	gross domestic product
GLASS	Global Antimicrobial Resistance and Use Surveillance System
I	interview
IAD	Institutional Analysis and Development
IPC	infection prevention and control
KEBS	Kenya Bureau of Standards
KFS	Kenya Fisheries Service
NAAS	networks of adjacent action situations
NAP	National Action Plan
NAP-AMR	National Action Plan for the Prevention and Containment of Antimicrobial Resistance
NASIC	National Antimicrobial Stewardship Interagency Committee
NEMA	National Environment Management Authority
NPHL	National Public Health Laboratory
OH	One Health
OHAMRS	One Health AMR Surveillance System
PPB	Pharmacy and Poisons Board
R&D	research and development
SOP	standard operating procedure
WRA	Water Resources Authority
WWTP	wastewater treatment plant
ZDU	Zoonotic Disease Unit

1 Introduction

Overuse of antimicrobials in human, animal and plant health sectors accelerates the natural process of developing resistance in several pathogens to these antimicrobials, rendering them ineffective (WHO, 2015). Further, antimicrobials are also transmitted from animals and plants treated with them in the form of residues when the food is consumed, leading to resistance in pathogens infecting humans (WHO, 2015). Yet another source and pathway for the spread of anti-microbial resistance (AMR) is the natural ecosystem (water, soil and air), which both act as a reservoir for AMR genes as well as a transmission vector by facilitating AMR exposure (UNEP, 2023). The multitude of factors and pathways for the emergence and transmission of AMR along the value chains of antimicrobials pose significant governance challenges for effective mitigation. A global assessment estimates that in 2019, AMR caused 6.19 million deaths and 82.34 million disability-adjusted life-years (DALYs), while highlighting major data gaps and the urgent need for coordinated action (Murray et al., 2022). Beyond the health toll, AMR is projected to cause economic losses of 1.1 to 3.8 per cent of global GDP by 2050, with LMICs facing losses of up to 5 per cent (Ahmed et al., 2018).

The Global Action Plan on Antimicrobial Resistance adopted by the World Health Assembly in 2015 emphasises the need for an "effective one health" approach for achieving its objectives. One Health is a concept that emerged out of the increasing recognition of the close interlinkages among human, animal, plant and ecosystem health, with a promise to foster synergies and reduce the negative impacts and trade-offs. It is "an integrated, unifying approach that aims to sustainably balance and optimise the health of people, animals and ecosystems. It recognises the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and interdependent" (One Health High-Level Expert et al., 2022). The political declaration of the 2016 High-Level Meeting of the United Nations General Assembly on AMR officially brought it into focus as a global common bad, and provided a fresh impetus for formulation and implementation of the national action plans (NAPs) for AMR drawn up by member countries. Despite the importance of the governance issues surrounding AMR, the policy and academic attention to this area have been largely inadequate. Following the dominant framing of AMR as a biomedical problem, efforts in finding solutions have predominantly focused on technical issues skewed in favour of human and animal health. Efforts to operationalise the One Health approach, which intends to foster integrated, cross-sectoral governance, have so far fallen short of effectively overcoming entrenched sectoral silos (Joshi et al., 2021). In particular, systematic analyses of the environmental dimensions of AMR and their associated governance challenges remain scarce (Taing et al., 2022). Systematic analysis of governance of AMR mitigation at any level has only recently begun. The first-ever comprehensive framework to assess the governance of AMR NAPs was developed by Anderson et al. (2019) and is only beginning to be applied for cross-country analysis and assessments of NAPs (Chua et al., 2021; Patel et al., 2023). The governance (analytical) framework also includes indicators on environmental dimensions of AMR, for example, existence of regulations or guidelines for the disposal of antimicrobial waste, inclusion of environmental experts in the development of the NAP, and existence of surveillance system for AMR pathogens in environment as an indicator (Anderson et al., 2019). Chua et al. (2021) find that only three (Thailand, Indonesia and Philippines) out of ten countries included in the study have environmental AMR surveillance systems, and that there are limitations on their implementation. Similarly, although five countries are reported having regulations or guidelines in place for the disposal of antimicrobial waste, including other pharmaceutical and disinfectants, the actual implementation remains weak.

The framework of Anderson et al. (2019) and its application for assessing the implementation of NAPs, although an important first step for analysing AMR governance, offers a very technical perspective on governance and does not consider the inherent complexities in the processes of designing and implementing the AMR control strategies in different sectors. Further, it falls short in assessing the effectiveness of the existing mechanisms for achieving coordination across sectors and levels, which is crucial for managing the cross-sectoral interlinkages. While environmental governance literature has extensively addressed coordination problems, applying these frameworks to AMR governance is just beginning. Weldon et al. (2024), draw lessons from 12 global and regional environmental governance frameworks, applying principles of common-pool resource management and polycentric governance to propose nine strategies for overcoming collective action dilemmas in AMR governance. However, they focus primarily on governance strategies for antimicrobial research and development (R&D), production, access, and stewardship, with less emphasis on coordination across human health, animal health and agricultural sectors or environmental transmission pathways.

Studies on environmental factors in AMR development and spread are limited. Although experts agree on their crucial role, research and policy attention remain inadequate (Booth et al., 2020; Taing et al., 2022). Reviewing three decades of research, Taing et al. (2022) show that "antimicrobial R&D" and "human consumption of antimicrobials" dominated, while food safety and water-related themes ("clean water and sanitation" and "environmental contamination"), especially in low-income and lower-middle-income countries disproportionately burdened by AMR, were overlooked. Booth et al. (2020) find antibiotic residues in soil, groundwater and surface water often exceed predicted no-effect environmental concentration values, indicating potential for resistance development. Yet most studies focus on exposure likelihood rather than quantifying human health risks (Hart et al., 2023). Limited understanding of the relative significance of sources and risks hampers effective technical and policy design (Larsson et al., 2018). Environmental factors also receive little attention in national and multilateral efforts: the Joint Programming Initiative on Antimicrobial Resistance lists environment as the least funded category (Wellcome, 2020). While a research community exists, policymakers and the AMR community often see the environment only as a transmission medium. Demonstrating the development of resistance in environmental contexts remains challenging, due to its relative rarity and the complexity of the underlying systems (Wellcome, 2020).

The underrepresentation of the environmental dimension in AMR emergence and transmission pathways likely stems from the inadequate operationalisation of the One Health approach across different levels. Weak multi-sectoral coordination poses a significant threat to the sustainable implementation of this approach, hindering the development of cross-sectoral resilience (dos S. Ribeiro et al., 2019). Although the necessity of integrated policies – and thus coordination among diverse actors across sectors and governance levels – is widely acknowledged, there remains a limited understanding of where such coordination is required and how it can be effectively achieved. While most AMR research predominantly focuses on surveillance of resistance patterns in human and animal health, there is a dearth of evidence as to what technical, socio-economic and institutional conditions foster or hinder coordination across sectors and levels. Similar coordination challenges, including sectoral fragmentation and power asymmetries, are evident in other integrated approaches, such as integrated water resources management and the water-energy-food-ecosystems nexus (Srigiri & Dombrowsky, 2022).

In order to fill the knowledge gap on governance and environmental dimensions of AMR mitigation, we chose to study the governance of AMR strategies in Kenya. Kenya has undergone major policy reforms, devolving authority over all relevant sectors for AMR to the county governments. Kenya also established the required institutional framework for collaboration across national and county governments through the Intergovernmental Relations Act (2012). In addition, Kenya has over a decade of experience in cross-sectoral coordination among the One Health sectors, starting with the National Strategic Plan for the Implementation of One Health in Kenya, 2012–2017 (Zoonotic Diseases Unit, 2012) to prevent the outbreak of zoonotic diseases, and the Kenya: National Action Plan on Prevention and Containment of Antimicrobial Resistance, 2017–2022 (Government of Kenya, 2017). With support from various bilateral and multilateral actors, Kenya made significant efforts in designing and implementing one health strategies to address zoonotic diseases and AMR.

The insights generated from this study aim to inform more effective design and implementation of One Health strategies in Kenya and other comparable contexts. To achieve this, the study applies a polycentric governance approach (V. Ostrom et al., 1961), which provides a valuable analytical lens for examining how multiple, overlapping decision-making centres interact, and how contextual factors shape their coordination and collective outcomes. Building on this, the paper investigates two key research questions:

1. What are the enablers and barriers to effective governance of interlinkages among human health, animal health and the environmental sectors in mitigating AMR development and spread?

2. What are the options for effectively integrating the environmental dimension into AMR governance?

The remainder of this paper is organised as follows. Section 2 establishes the theoretical foundation by outlining key concepts and presenting the analytical framework used to examine coordination in AMR mitigation governance. Section 3 describes the study's methodology. Section 4 explores the environmental dimensions of AMR in Kenya through a review of empirical literature, and provides a comprehensive overview of the formal institutional framework addressing AMR emergence, transmission, prevention and control across sectors. Section 5 applies the analytical framework to examine coordination mechanisms for AMR prevention and control in Kenya. Section 6 discusses these results in light of theoretical propositions and the wider empirical literature. The final section offers policy recommendations and identifies areas for future research.

2 Coordination in One Health-based governance of AMR – analytical framework

Antimicrobial resistance (AMR) presents a quintessential collective action challenge. It emerges from dispersed decisions across human, animal and environmental domains, but its consequences transcend sectoral boundaries. A polycentric governance perspective through its emphasis of coexistence of multiple centres of decision-making, each operating with a degree of autonomy while being functionally interdependent (V. Ostrom et al., 1961), allows for a more nuanced analysis. This lens enables us to systematically explore how actors in different sectors and at different levels interact, coordinate and adapt their responses to the shared problem of AMR. It also highlights the ways in which intentional coordination mechanisms, such as One Health platforms and inter-sectoral AMR coordination committees, interface with more informal networks, thereby influencing both policy design and implementation.

To operationalise polycentric governance for the study of AMR mitigation, we draw on the Institutional Analysis and Development (IAD) framework (E. Ostrom, 1990) and the concept of the network of adjacent action situations (NAAS) (McGinnis, 2011). The IAD framework provides an analytical structure for examining how actors interact in action situations defined by rules-in-use, material conditions and community attributes, and how these interactions generate outcomes. It has been widely applied in analysing governance of common-pool resources and public goods, where coordination among diverse actors is necessary for their sustainability (Anderies, Janssen, & Ostrom, 2004; E. Ostrom, 2012). The IAD framework and the concept of NAAS have been used to study interlinked policy issues such as the water–energy–food–ecosystems nexus (Kimmich, 2013; Srigiri & Dombrowsky, 2022; Villamayor-Tomas, et al., 2015).

Building on the IAD, McGinnis (2011) extends the analysis to networks of adjacent action situations (NAAS). Action situations rarely occur in isolation; instead, they are nested or adjacent, with the outcomes of one shaping the conditions of others. For example, decisions made in collective-choice arenas (such as national planning processes) define the rules structuring operational-level practices (such as the management of hospital waste), while constitutional-level arenas set the procedures for establishing and legitimising these rule-making processes. The NAAS perspective emphasises the interdependencies among action situations, thus capturing the complexity of governance in polycentric systems.

For our study, the combination of IAD and NAAS is particularly advantageous because it enables us to examine (i) focal action situations of antimicrobial use and waste treatment at the operational level, (ii) their interlinkages with adjacent situations such as regulation, planning and resource allocation, and (iii) the overarching coordination mechanisms across One Health sectors. In the remainder of this section, we describe different components of the analytical framework by contextualising it in the case study, as depicted in Figure 1.

Action situations: An action situation is an analytical concept that allows researchers to focus on the immediate structural conditions influencing a process of interest, with the aim of explaining recurring patterns of human behaviour and outcomes (E. Ostrom, 1990, p. 11). It refers to a social space in which multiple actors occupy defined positions and select from among available actions, producing outcomes that generate varying consequences or payoffs for the participants involved. According to McGinnis (2011), a *focal action situation* is the central situation of analytical interest where actors make interdependent choices that produce specific outcomes (such as resource exploitation or service delivery), while an *adjacent action situation* is one whose outcome "directly influences the value of one or more of the working components" of the focal action situation (p. 53), thereby shaping its parameters, payoff structures or equilibrium outcomes. A systematic review by Kimmich et al. (2023) of empirical research on networks of action situations identified six different approaches for delineating the boundaries of action situations, which can be grouped into inductive approaches that identify social interactions causally influencing outcomes of interest (often using process tracing), and concept-driven approaches that mobilise predefined concepts such as resource systems, governance functions, jurisdictional boundaries or value chain stages. While this diversity reflects necessary case sensitivity and contributes to methodological development, the review emphasises that more explicit and consistent reporting of boundary delineation procedures is needed to enable knowledge accumulation across studies.

In the context of AMR governance in Kenya, we delineate action situations following a hybrid approach that combines governance functions (planning, resource allocation, regulation) with resource systems and sectoral boundaries (health, veterinary, fisheries, wastewater treatment), informed inductively through stakeholder interviews and document analysis (cf. Kimmich et al., 2023). This delineation yielded operational-level action situations such as antimicrobial prescription and disposal in health and veterinary sectors, and treatment of wastewater and solid waste, alongside collective choice situations for planning, resource allocation and regulation (Figure 1). The action situations delineated for analysis in this study are still dense, and in fact constitute multiple sub-action situations in reality. This is true to most empirical studies using action situations as analytical units, where action situations are "somewhat aggregated" (Thiel et al., 2025, p.23), leaving room for narrower definitions and more fine-grain analysis.

In applying this framework, we focus on the focal action situation of the implementation of the AMR mitigation strategies enshrined in Kenya's National Action Plan on the Surveillance and Containment of Antimicrobial Resistance (NAP-AMR) – such as surveillance, stewardship and awareness raising – at the operational level. Adjacent action situations span both operational and collective choice levels. While it is an impossible task to conduct an in-depth analysis of the entire spectrum of individual action situations at all levels of analysis (constitutional, collective and operational), what we identify in this study is a map of key (aggregated) action situations at various analytical levels. Further, we deliberately exclude action situations that would have been part of the constitutional choice level from our analysis, such as political and parliamentary processes that result in rules-in-use for the action situations in collective and operational choice levels. While these processes determine the rules-in-use at the collective choice level, it was not feasible to include this in the scope of the current study.

Collective choice level:

- Planning and design (action situation 1): where national priorities and coordination mechanisms are established.
- Resource allocation (action situation 2): determining the financial and human resources available to different sectors.

Operational level:

- Prescription, use and disposal (action situations 3 and 4): day-to-day practices in health care, veterinary and fisheries sectors.
- Waste treatment (action situation 5): addressing effluents and solid waste management.
- Regulation (action situation 6): setting and enforcing standards, particularly for pharmaceutical residues and hospital/industrial waste.

Together, these action situations form a network whose interactions determine both intermediate outcomes (e.g. compliance, resource flows monitoring data) and overall governance outcomes (e.g. reduction of AMR in human, animal and environmental systems). Feedback loops link these outcomes back into rule-making processes at the collective choice level.

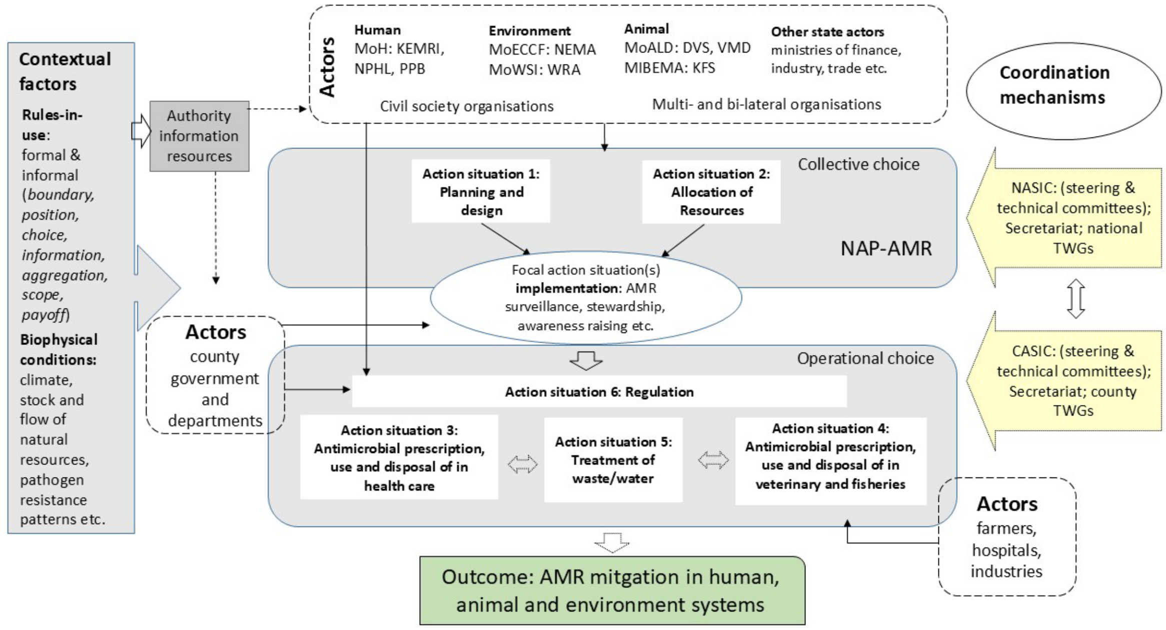
Actors and positions: Each action situation comprises multiple actors, who may be individuals or an organised entity of individuals – ministries, agencies, hospitals, farms, industries, county governments – occupying specific positions (e.g. regulators, service providers, resource users). National and county AMR coordination committees (NASIC, CASIC) and technical working groups provide cross-cutting platforms for interaction.

Rules-in-use: Rules define the structure of action situations by constraining or enabling actor choices. Ostrom (2005) distinguishes seven types:

- *Boundary rules* define who is included (e.g. which institutions have mandates over AMR surveillance or waste regulation).
- *Position rules* assign roles (e.g. ministries vs. local governments).
- *Choice rules* specify allowable actions (e.g. discharge limits for effluents).
- *Information rules* govern data collection and sharing (e.g. AMR surveillance reporting).
- *Aggregation rules* determine decision-making procedures (e.g. consensus in One Health platforms).
- *Payoff rules* assign costs and benefits (e.g. sanctions for non-compliance).
- *Scope rules* set the range of outcomes (e.g. targets of the NAP-AMR).

These rules emerge from distinct adjacent action situations and can be both formal (laws, regulations) and informal (norms, professional standards).

Figure 1: Network of action situations in AMR mitigation – a framework for institutional analysis



Notes: **NASIC**: National Antimicrobial Stewardship Interagency Committee; **CASIC**: County Antimicrobial Stewardship Interagency Committee; **TWG**: technical working group; **MoH**: Ministry of Health; **KEMRI**: Kenya Medical Research Institute; **NPHL**: National Public Health Laboratory; **PPB**: Pharmacy and Poisons Board; **MoECCF**: Ministry of Environment, Climate Change and Forests; **NEMA**: National Environment Management Authority; **MoWSI**: Ministry of Water, Sanitation and Irrigation; **WRA**: Water Resources Authority; **MoALD**: Ministry of Agriculture and Livestock Development; **VMD**: Veterinary Medicines Directorate; **DVS**: Directorate of Veterinary Services; **MIBEMA**: Ministry of Mining, Blue Economy and Maritime Affairs; **KFS**: Kenya Fisheries Service; **NAP-AMR**: National Action Plan on AMR

Source: Adapted from E. Ostrom (1990); McGinnis (2011); Koontz & Garrick (2019)

Biophysical and material context: Action situations are embedded in biophysical and infrastructural systems that condition both risk transmission and the feasibility of interventions. From an IAD/NAAS perspective, biophysical attributes (e.g. climate variability, water flow regimes, dispersion pathways, persistence/decay of contaminants, pollution loads, pathogen resistance patterns) shape actors' feasible choice sets and the transaction costs of coordination, while material infrastructures (sewerage, treatment, solid-waste and laboratory systems) define technological possibilities and constraints. These conditions influence rules-in-use and their effecttiveness, such as: what can be measured reliably; at what frequency and scale (information rules); when and where can joint inspections or synchronised sampling be practicable (aggregation rules); and which outcome targets can realistically be monitored and regulated (scope rules) etc.

Coordination: Coordination is one of the core elements of focus in the polycentric governance approach. V. Ostrom et al. (1961) propose that in a polycentric system, the process of public good provision involves independent decision-centres interacting with each other, and that these interactions or interrelationships are based on the principles of *competition*, *cooperation* and *coercion*. While having recourse to a centralised authority for conflict resolution embodies the coercive or hierarchical interrelationship, *conflict* is considered as the implicit fourth form of interrelationship, which is rather uncoordinated (Thiel et al., 2025). According to this understanding (un-)coordination, whichever form it takes, is integral to all action situations and is structured by multiple contextual factors, along with the rules-in-use in that particular action situation. As Thiel et al. (2025) observe, in most empirical analyses, due to their broad delineation of action situations, hybrid modes of coordination are often at play, even if one mode dominates the others (p. 28). Further, McGinnis (2011) interprets coordination as one of the key functions of a polycentric governance system and proposes that it constitutes an action situation in itself, just as for all other governance functions of production, provision, financing and dispute resolution. The purposive mechanisms such as multi-sectoral coordination committees and working groups for AMR at national and sub-national levels could correspond to such action situations. Such mechanisms may fulfil the functions of coordination both across levels and sectors. This calls for a more distinguished understanding of which coordination modes or combinations of coordination modes is relevant for particular studies and research questions.

The three principles of interrelationships form the basis of three stylised modes of coordination, namely, *networks* (cooperative), *markets* (competitive) and *hierarchies* (coercive) modes (Pahl-Wostl, 2019a, 2019b; Thiel et al., 2025). These modes of coordination further differ structurally, according to Pahl-Wostl (2019b). Hierarchies are characterised by bureaucratic structures where regulatory processes rely on formal rules and sanctions, steering is based on authority, and power derives from one's position in the formal hierarchy. Networks operate largely through informal institutions, with steering based on trust and voluntary agreements, where power derives from one's centrality and role within the network. Markets combine formal and informal institutions, with steering based on price mechanisms and economic incentives, where actors are primarily motivated by material benefits, and power derives from wealth and access to resources. There are also marked differences in the way three modes of coordination function (Pahl-Wostl, 2019b). For instance, hierarchical modes emphasise technocratic expertise and output legitimacy achieved through democratic representation, while network modes value diverse knowledge types, participatory processes, and input legitimacy based on inclusive participation. Market modes prioritise knowledge for competitive advantage and efficiency-based legitimacy. In conflict resolution, hierarchical modes rely on jurisdiction and legal procedures, network modes favour mediation and consensus-building, and market modes operate through competition and compensation payments (Pahl-Wostl, 2019b).

In the context of water governance, Pahl-Wostl (2019b) argues that hybrid governance systems combining all three modes in synergistic interplay are essential for addressing complex management challenges, as each mode has distinct strengths and weaknesses. However, combining these modes is challenging because they operate under incompatible logics, potentially leading to conflicts rather than synergies (Pahl-Wostl, 2019b). The development and maintenance of effective hybrid governance systems requires meta-governance – a reflexive process of societal learning to develop, evaluate and adapt governance approaches (Pahl-Wostl, 2019b). This involves both purposeful design and self-organisation, with government ideally playing an active coordinating role while avoiding the dominance of any single mode (Pahl-Wostl, 2019b).

Purposively designed coordination mechanisms in the Kenyan case include inter-ministerial committees and technical working groups at national and county levels for implementing the NAP-AMR. Informal mechanisms – trust, professional networks, personal relations – also affect interactions (Carlisle & Gruby, 2019; Morrison et al., 2017). These formal and informal mechanisms structure how authority, information and resources are shared, often privileging human health while environmental actors remain less empowered (Koontz & Garrick, 2019).

Authority, information, and resources:

Building on Koontz and Garrick (2019), three dimensions are central to understanding how action situations connect and how coordination unfolds.

Authority defines who has the legitimacy to make decisions, enforce rules, or allocate resources. It is linked to boundary and position rules: authority determines which actors are included in governance processes and what roles they are permitted to exercise. Unequal authority distribution, such as privileging human health agencies over environmental regulators, affects coordination by skewing decision-making power and prioritising certain activities and outcomes over others. The distribution of authority also fundamentally shapes governance mode choice and effectiveness (Pahl-Wostl, 2019b). In hierarchical governance, authority is centralised within formal governmental structures, enabling top-down steering through regulation and sanctions. In network governance, authority is dispersed among multiple actors who coordinate through trust-based relationships, with power deriving from one's centrality and role within the network rather than formal position. In market governance, authority operates through economic mechanisms, with actors holding power based on their wealth and market share. Mismatches between authority distribution and governance mode can create conflicts – for example, when governments with hierarchical traditions attempt to implement network-based participatory approaches while retaining final decision-making authority, undermining the legitimacy of the participatory process.

Information is critical for transparency, accountability and adaptive learning. It connects to information rules and aggregation rules, determining how knowledge (e.g. surveillance data, compliance records, risk assessments) is generated, shared and integrated into decisions. Where information flows are transparent and accessible, coordination is facilitated; where information is fragmented or withheld, trust erodes and collective action weakens. Different governance modes value and utilise information fundamentally differently, affecting their capacity to address complex problems (Pahl-Wostl, 2019b). Hierarchical modes emphasise technocratic expertise and formal technical knowledge for effective regulation, with experts playing dominant roles. Network modes acknowledge diverse knowledge types (technical, local experiential) and promote broad knowledge sharing as part of group-building processes, enabling more adaptive and context-sensitive approaches. Market modes treat knowledge as competitive advantage and commodity. These differences have important implications for coordination: hierarchical technocratic traditions may struggle with implementing participatory requirements that value diverse stakeholder knowledge, creating barriers to learning and innovation needed for adaptive AMR governance.

Resources (financial, human, and technical) are the basis for carrying out responsibilities. They relate to payoff rules and scope rules, since they determine what outcomes are achievable and what incentives or sanctions can be imposed. Unequal distribution of resources often hampers coordination. Actors with mandates but insufficient resources may struggle to comply or enforce rules, while well-resourced actors may dominate decision-making. Resource distribution patterns interact critically with governance mode choice and effectiveness (Pahl-Wostl, 2019b). Fiscal decentralisation that grants financial autonomy to certain actors (a market-oriented element) can create tensions with hierarchical control when resource-autonomous actors pursue short-term economic objectives over long-term sustainability goals. Conversely, failure to provide adequate resources to decentralised implementing bodies undermines intended shifts toward more participatory or network-based governance. Effective coordination requires that resources are sufficient to support mandated responsibilities, and are distributed in ways that align with the chosen governance mode.

Together, authority, information and resources shape both formal and informal coordination. They determine which actors can meaningfully participate, how decisions are reached, and whether commitments can be implemented. Effective polycentric governance depends on aligning these dimensions across action situations so that authority is legitimate, information is reliable and shared, and resources are sufficient and fairly distributed. This alignment requires meta-governance to coordinate how these dimensions are distributed and utilised across different governance modes, ensuring synergies rather than conflicts in addressing complex AMR challenges.

Outcomes: As McGinnis (2011) highlights, outcomes of action situations can be material (changes in AMR prevalence, environmental loads) or institutional (shifts in norms, trust, capacities). In Kenya's AMR governance, outcomes are shaped not only by sectoral mandates and resources, but also by coordination dynamics among multiple centres of authority. Polycentric governance analysis, via the IAD and NAAS frameworks, enables us to assess whether current arrangements foster cooperation, reinforce silos, or allow powerful actors to circumvent rules, thereby determining the effectiveness of One Health strategies for AMR mitigation.

3 Research methods

The lack of sufficient scientific knowledge on environmental transmission pathways is highlighted as a major impediment in the way of designing appropriate policy instruments for controlling the environmental AMR (Larsson et al., 2018). Further, the sporadic and non-systematic studies so far were not able to substantiate either the directionality or impact of a specific pathway or risk linkage. Therefore, in the given context, it is not only difficult to design appropriate measures, but also challenging to conduct a hypothesis-driven inquiry of governance issues for mitigating specific pathways. In this study, we apply a qualitative case study approach (Yin, 2003), which is suitable to the current context, in which an explorative and inductive inquiry needs to be conducted in order to understand an array of conditions that could plausibly mediate the effective mitigation of AMR, focusing on the environmental domain. Therefore, the study explores to what extent the existing governance mechanisms are able to manage the key interlinkages among strategies pursued in different decision-making centres across sectors and levels that have an impact on AMR and its mitigation, especially in the environmental domain.

Literature review and document analysis

Context-specific literature on AMR mitigation in Kenya will be reviewed in depth to understand the key interlinkages among the food, environment and health sectors pertaining to the AMR development and transmission, and to its prevention and control. Further policy documents pertaining to related sectors, including key legislations, plans, and implementation guides for tools and their evaluations, will be reviewed to understand not only the existing governance structures for AMR prevention and control, but also the governance of sectors themselves with respect to AMR.

Data collection

Primary data was collected through 12 semi-structured interviews with key informants from different sectors during 2023 to 2024. Interviewees (Annex 1) included members of the National Antimicrobial Stewardship Interagency Committee (NASIC), decision-makers from relevant ministries (environment, human health and animal health), civil society organisations, AMR focal points of organisations involved in the Multi-Partner Trust Fund for Kenya, as well as other domain experts. At the sub-national level, three members of County Antimicrobial Stewardship Interagency Committees (CASICs) of Nairobi and Kisumu counties and technical personnel of a wastewater treatment plant were also interviewed. Key informants were selected both through prior identification of stakeholders relevant to AMR governance and through a snowballing approach.[1] All interviews were conducted in Nairobi.

In addition to interviews, field notes from meetings with three key stakeholders were incorporated into the analysis. These meetings brought together representatives from government agencies, international organisations, and civil society to discuss ongoing strategies for AMR prevention and control. While these meetings were not designed as research interviews,

1 The snowballing approach (or snowball sampling) is a purposive sampling technique in which initial key informants identify additional relevant participants from their professional or social networks, thereby expanding the sample through successive referrals (Noy, 2008).

systematic observations and notes were recorded to capture insights into cross-sectoral interactions, coordination challenges and emergent governance issues.

Data analysis

Interview transcripts and field notes were analysed using a qualitative content analysis approach. Data were coded and thematically organised according to the components of the analytical framework using Atlas.ti (version 25), which served as the central tool for data management and analysis. Literature, policy documents and observational notes from stakeholder meetings were used to triangulate and contextualise the interview data.

Limitations

Although the study aimed to reach thematic saturation through iterative interviews with key informants from human, animal and environmental health sectors, practical constraints limited access to certain institutional representatives. Consequently, complete saturation, defined as the point where no new themes emerge (Guest et al., 2006; Hennink et al., 2017), may not have been achieved. The findings therefore do not represent an analytically exhaustive picture of One Health governance arrangements and challenges in Kenya. Triangulation with policy documents, evaluation reports, notes from meetings with stakeholders and workshops was used to enhance the robustness of the results, despite the limited number of interviews.

4 Environmental dimensions of AMR and formal institutional framework for AMR mitigation in Kenya

4.1 Emergence and transmission of AMR in environment in Kenya – empirical evidence

Antimicrobial resistance poses a significant and growing public health threat in Kenya, with an estimated 37,259 AMR-associated deaths in 2019 (Murray et al., 2022). To put this in perspective, this represents approximately 68 deaths per 100,000 population in Kenya, substantially higher than the global average of 13.6 deaths per 100,000, positioning Kenya among the countries most severely affected by AMR globally (Murray et al., 2022). While the highest deaths were attributed to multi-drug resistant (MDR) Klebsiella pneumoniae, E. coli, to which the second highest number of deaths were attributed, was resistant to a greater number of drugs (Murray et al., 2022). There is a growing evidence base that suggests the importance of environmental pathways for development and transmission of AMR in Kenya. Residues of antibiotic and other active pharmaceutical ingredients exceeding predicted no effect environmental concentration (PNEC) levels in municipal wastewater have been identified by various studies as a major contributor of antimicrobial load in environment in Kenya. For example, see Kairigo et al. (2020) and Muriuki et al. (2020) for studies in Kiambu, Machakos, Nyeri and Meru counties, Kimosop et al. (2016) in Lake Victoria Basin, and Ngigi et al. (2019) and K'Oreje et al. (2016) in Nairobi and Kisumu counties. Most studies have identified domestic and hospital waste as major contributors of antimicrobial residues found in wastewater and solid waste sites. Improper use and disposal patterns are found to be prevalent in several regions, for example, informal settlements of Kisumu town by Karimi et al. (2023) and in Kakamega town by Malaho et al. (2018). While domestic and medical wastes are all discarded into common sewer lines (liquid) and dump-sites (solid), sewage treatment plants in Kenya do not treat waste to eliminate enteric microbes (Malaho et al., 2018).

Studies that assessed the risk quotient[2] of a selection of antibiotic-resistant bacteria in environment in various study sites in Kenya revealed a medium to high risk of resistance selection (for example, see Kairigo et al. (2020) for wastewater and Yang et al. (2016) for soils). Multi-drug-resistant strains of Enterobacteriaceae family, majorly *Escherichia coli* (*E.coli*) were found in various study areas. For example, see Wahome et al. (2014) for studies in groundwater of Kajiado North County, Wambugu et al. (2015) in Athi River in Machakos county, and Malaho et al. (2018) in wastewater and dumpsites in Kakamega town.

4.2 One Health and AMR strategies in Kenya – status of environmental integration

4.2.1 One Health strategies

Kenya's adoption of the One Health (OH) approach has been incremental, beginning with the establishment of the Zoonotic Disease Unit (ZDU) in 2012, following lessons from earlier zoonotic outbreaks such as Rift Valley Fever. The OH approach has since been reinforced through strategic planning processes, including the National strategic plan for the implementation of One Health in Kenya (2012–2017) (Zoonotic Diseases Unit, 2012) and the updated One Health strategic plan (2021–2025) (Republic of Kenya, 2021). These frameworks emphasise multi-sectoral collaboration in surveillance, prevention and control of zoonotic diseases, and provide a foundation for integrating AMR as a cross-cutting challenge (Bukachi et al., 2024). The OH coordination structure is anchored in the ZDU, which brings together experts from the Ministry of Health and the Ministry of Agriculture and Livestock Development, though the environment ministry has historically been less represented. Despite progress, reviews highlight that coordination remains stronger in zoonotic disease control than in environmental health integration.

4.2.2 Strategies to prevent and control AMR

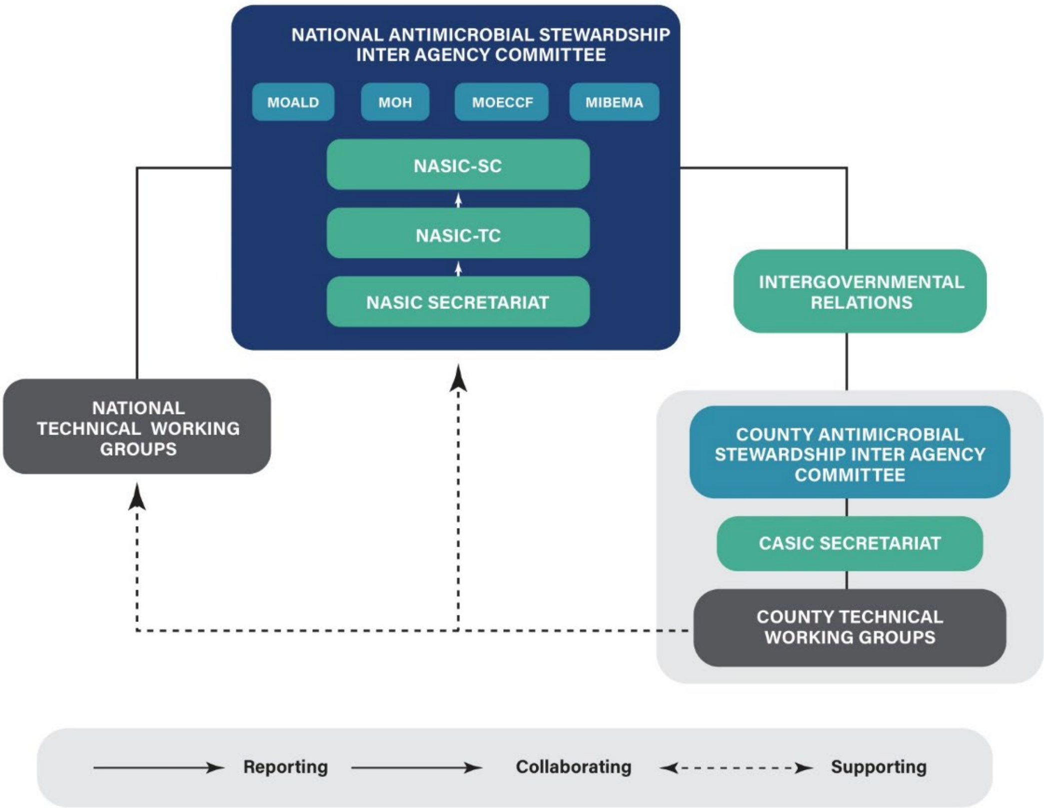
Kenya drafted its first national policy and National Action Plan for Prevention and Containment of AMR (2017–2022) in 2017 (Government of Kenya, 2017), largely aligned with the WHO Global Action Plan on AMR (WHO, 2015). The NAP-AMR (2017–2022) focused on surveillance of AMR pathogens in humans and animals, infection prevention and control (IPC), and research and development. A governance structure (Figure 2) was established through the National Antimicrobial Stewardship Interagency Committee (NASIC), co-chaired by the Ministry of Health and Ministry of Agriculture, Livestock and Fisheries, and including members from the environment, education, treasury and trade sectors (Government of Kenya, 2017). The NASIC structure includes a steering committee, a technical committee, a secretariat, and five technical working groups (TWGs) corresponding to the objectives of the Global Action Plan on AMR. County-level AMR governance was initiated through County Antimicrobial Stewardship Interagency Committees (CASICs), although by the end of the first NAP period only 18 of 47 counties had constituted CASICs (Mukoko et al., 2025).

While these efforts marked an important step, environmental dimensions were weakly integrated. Surveillance and monitoring focused primarily on human and animal health, with little systematic inclusion of the environment. According to WHO's Tracking Antimicrobial Resistance Country Self-assessment Survey (TrACSS), environment and food safety actors in Kenya were

2 Risk quotient is the ratio of the measured or predicted environmental concentrations of specific pollutants (antimicrobials) (MEC or PEC) to their predicted no-effect concentrations (PNEC) for specific antimicrobials. A RQ less than 0.1 indicates "low risk"; between 0.1 and 1 indicates "medium risk", and a value above 1 indicates "high risk" (Kairigo et al., 2020; Yang et al., 2016)

not sufficiently involved in the design of the first NAP-AMR and its implementation (Organization, 2022) (WHO, 2022). It addressed environmental contamination only indirectly, through hygiene, sanitation, and waste disposal measures in food production. Guidelines specific to environmental AMR mitigation were lacking (WHO, 2022). Shamas et al. (2023) identify cross-sectoral collaboration as a persistent challenge in implementing antimicrobial stewardship tools, alongside regulatory and capacity gaps.

Figure 2: Structure of coordination mechanism for AMR mitigation



Source: Government of Kenya (2023)

The second NAP-AMR (2023–2027) incorporated lessons from the first phase and broadened the scope to include the environment and fisheries, reflecting growing recognition of AMR as a One Health issue (Government of Kenya, 2023). Yet, integration remains partial. Environmental surveillance is still at an early stage, with initiatives such as the WHO Global Tricycle Protocol on ESBL-producing *E. coli* offering a potential entry point (WHO, 2021). Effective integration requires not only data collection but also institutional mechanisms to coordinate environmental, health and agricultural policies under the food–environment–health (FEH) nexus.

4.2.3 Coordination between AMR and One Health strategies

Kenya's AMR and OH strategies share common ground in their multi-sectoral orientation and reliance on inter-ministerial committees. The OH framework, anchored in the Zoonotic Disease Unit, and the AMR governance structure, anchored in NASIC, operate in parallel with overlapping memberships. However, coordination is not fully institutionalised. AMR governance has been housed outside the ZDU, leading to parallel rather than integrated processes (Bukachi et al., 2024; Mukoko et al., 2025). This fragmentation is compounded at county level, where CASICs and OH focal points are evolving separately, with uneven progress across counties (Government of Kenya, 2023).

Both processes emphasise the importance of surveillance, stewardship and public awareness, yet environmental integration remains limited in practice. Reviews highlight underrepresentation of the environment sector, fragmented funding streams, and weak linkages between national and county governance structures (WHO, 2022). Kenya's experience demonstrates that while significant progress has been achieved in establishing governance frameworks, the coordination between OH and AMR strategies is still insufficient. Stronger institutional integration, explicit inclusion of environment in AMR governance, and harmonised implementation at county levels remain key gaps.

4.3 Legal framework for mitigation of antimicrobial and AMR pathogen pollution in Kenya – implications for environmental AMR

Kenya's legal framework for antimicrobial resistance (AMR) illustrates how multi-sectoral coordination is anchored in both public health and environmental policies (Table 1). The National Action Plans on the Prevention and Containment of AMR (2017–22; 2023–27) form the cornerstone, providing strategic direction for integrating human, animal and environmental health under the One Health paradigm (Government of Kenya, 2017; Government of Kenya, 2023). These plans emphasise infection prevention, sanitation, surveillance and stewardship, which indirectly reduce antimicrobial residues and resistant pathogens entering environmental systems. Complementary to this, the National Antimicrobial Stewardship Guidelines for Health Care Settings in Kenya (Ministry of Health, 2020) address misuse and over-the-counter access to antimicrobials, a critical driver of environmental contamination through improper disposal and excretion.

The Pharmacy and Poisons Act (Cap 244) and recent Pharmacovigilance Guidelines (Pharmacy and Poisons Board, 2023b) ensure the quality and safety of pharmaceuticals, thereby indirectly limiting the circulation of substandard or unsafe antimicrobials that can accumulate in ecosystems. These measures are reinforced through the appointment of Qualified Persons for Pharmacovigilance (Pharmacy and Poisons Board, 2023a), strengthening Kenya's institutional oversight of antimicrobial products.

Environmental pathways are most directly addressed through Kenya's healthcare waste and biosafety policies. The National Policy on Injection Safety and Medical Waste Management (Republic of Kenya, 2007), the updated Kenya National Guidelines for Safe Management of Health Care Waste (Republic of Kenya, 2011/2024), and the associated standard operation procedures (SOPs) (Republic of Kenya, 2017) provide detailed frameworks for managing pharmaceutical and hazardous waste. These guidelines explicitly promote best available technologies (BATs) and best environmental practices (BEPs), reducing the risks of resistant pathogens spreading via unsafe incineration or landfill disposal. The Laboratory Biosafety and Biosecurity Policy (Republic of Kenya, 2014) further mitigates risks of accidental release of AMR pathogens.

At a broader scale, foundational environmental laws such as the Environmental Management and Coordination Act (Republic of Kenya, 1999), the Water Quality Regulations (Republic of Kenya, 2006), and the Water Act (Republic of Kenya, 2016) establish legal authority to regulate discharges and safeguard water bodies. These frameworks are particularly important, as water environments often serve as reservoirs for antimicrobial residues and resistant microorganisms. Together, these legal instruments create a multi-layered governance structure linking AMR control with pollution prevention and environmental protection.

In sum, Kenya's environmental governance framework highlights that AMR prevention and control extend beyond health facilities into waste management, water quality regulation and biosafety systems. The convergence of these policies demonstrates a comprehensive One Health approach, though challenges remain in enforcement capacity, coordination across agencies, and addressing under-regulated sources such as hospital effluents and industrial discharges.

Table 1: Legal/regulatory framework for AMR in Kenya – implications for environmental AMR

Regulation/policy	Main focus/provisions	Relevance for environmental AMR mitigation
National Action Plan on Prevention and Containment of AMR (2017–2022; 2023–2027)	Strategic guidance across sectors on AMR, coordination, stewardship, surveillance and awareness	Integrates environment within One Health; stresses sanitation, hygiene and infection prevention to reduce AMR spread in ecosystems
National Antimicrobial Stewardship Guidelines (2020)	Optimising antimicrobial use, reducing over-the counter misuse, strengthening lab capacity	Addresses indirect AMR drivers by minimising inappropriate antimicrobial release into the environment
Pharmacy and Poisons Act, Cap 244 & Pharmacovigilance Guidelines (2023)	Regulation of pharmaceuticals; monitoring quality, safety and adverse events	Indirectly prevents circulation of substandard or unsafe antimicrobials that could worsen AMR reservoirs
National Policy on Injection Safety & Medical Waste Management (2007)	Safe injection practices, disposal of sharps and medical waste	Reduces risk of contaminated waste entering the environment and spreading resistant pathogens
National Guidelines for Safe Management of Health Care Waste (2011; updated 2024)	Safe waste handling, treatment and disposal; adoption of BATs and BEPs.	Directly prevents environmental contamination from pharmaceutical and medical waste, limiting AMR spread
Healthcare Waste Management Guidance and Standard Operating Procedures (2017)	Operational procedures for safe management of healthcare waste	Provides practical implementation guidance to reduce risks of environmental AMR pollution
Laboratory Biosafety and Biosecurity Policy Guidelines (2014)	Standards for biosafety and biosecurity in labs	Prevents accidental release of resistant pathogens into the environment
Environmental Management and Coordination Act (1999)	Foundational law on waste and pollution management	Legal framework for regulating disposal of pollutants including antimicrobials
Water Quality Regulations (2006)	Prohibits discharge of toxic, noxious substances into water bodies	Prevents antimicrobial residues and resistant organisms from contaminating aquatic ecosystems
Water Act (2016)	Regulates water use and management, ensures minimum reserves	Protects water resources, indirectly safeguarding against AMR spread via water contamination

Source: Authors' compilation

5 Results – coordination for AMR prevention and control in Kenya

This section draws on interviews with key informants across human health, animal health, environment and water agencies, regulators, researchers and county platforms. The interview transcripts were coded according to the categories outlined in the analytical framework in Section 2 and are presented as a set of action situations. For each action situation, we describe the principal actors and their attributes, how they interact or coordinate, rules-in-use – boundary, position, choice, aggregation, information, payoff and scope rules – that shape those interactions, and the main outcomes observed.

5.1 Action situations

Focal action situation: Implementation of the NAP-AMR (surveillance, stewardship, awareness)

Key Actors: At the national level, the National Antimicrobial Stewardship Inter-Agency Committee (NASIC) Secretariat, constituted by the representatives of Ministry of Health; Ministry of Agriculture Livestock and Fisheries (Directorate of Veterinary Services; Department of Fisheries[3]); Ministry of Environment, Climate Change and Forestry (National Environment Management Authority (NEMA)), coordinates day-to-day NAP implementation, convenes national technical working groups, and steers surveillance, infection prevention and control (IPC), stewardship, and awareness activities. Counties operationalise the plan through CASICs; about 15 had been inaugurated by late-2023, with eight having launched work plans, and some counties integrating AMR into broader One Health units (I9). In parallel, sector regulators and implementers carry mandate-specific functions that intersect with AMR: NEMA (environmental compliance, permits, standards, inspections), which supervises or coordinates all environmental matters and regulates effluents/solid waste, including hospital and pharmaceutical waste streams (I5); the Directorate of Veterinary Services (surveillance in priority value chains, farm biosecurity, prudent use) (I10); and Kenya Fisheries Service (standards, residue monitoring, labs not yet fully operationalised for AMR) (I6). County CASICs are typically anchored in county departments of health, with participation from animal health and environment officers; Nairobi and Kisumu are examples of human health focal persons serving as secretaries and liaisons to NASIC (I7; I11).

The interviews underscore mandates and gaps. As a respondent noted, while Kenya has water/air/solid-waste regulations and hospital-waste standards, “the issue of AMR is not there… not even antimicrobials” in inspection checklists or required effluent tests, highlighting a key environmental blind spot now under review (I5). Further, the KFS too “sit[s] at the national steering committee,” but “the first NAP did not take into consideration so much issues on fishery… we do not have data,” with three labs equipped but not fully operational due to lack of availability of consumables, especially reagents (I6).

Coordination mechanisms (NASIC and CASIC): Nationally, coordination is formalised through the NASIC Steering Committee, a multisector Secretariat, and technical working groups for advocacy, surveillance/monitoring, infection prevention and control (IPC), and stewardship; the lack of an R&D technical working group was noted as a gap to be addressed in NAP II (I9). Meeting frequency is at least quarterly (ideally monthly), with reporting channelled via TWGs

3 The Department of Fisheries was later merged into the Ministry of Mining, Blue Economy and Maritime Affairs (MIBEMA) and is now known as Kenya Fishery Service. In the new National Action Plan for AMR, MIBEMA is added as a member of NASIC.

and projects. The current NAP is costed “by thematic area, intervention and activity”, with implementing agencies specified (I9). Counties mirror this structure: CASICs adopt One Health membership, develop costed two-year work plans, and report upward to the County Authority and their respective Ministries at the national level. Kisumu’s CASIC meets quarterly, runs five strategic objectives, and uses media partnerships (vernacular radio) to extend awareness; however, environment actions lag without a strong partner (I7). Nairobi’s new CASIC prioritises hospital AMS programmes and antibiograms, but faces procurement and staffing constraints and is exploring adding NEMA representation (I11).

The coordination mechanism currently at work is illustrated by the following quote: “We… co-developed our priority interventions… [and] a monitoring and evaluation framework”, anchoring many activities in existing ministerial programmes while leveraging partner projects for joint One Health implementation (I9). The respondent from Kisumu described CASIC reporting lines and partner mapping to leverage HIV/TB/malaria infrastructures for AMR (I7). Nairobi’s AMS lead emphasised mentorship links (with Fleming Fund and university partners) to build facility-level stewardship that can become a county “centre of excellence” (I11).

Hierarchy is visible in the formal, rule-bound architecture: the principal secretary and director chair the NASIC; counties adopt structured CASICs; sector regulators (NEMA, DVS, KFS) exercise statutory powers (I5, I6, I9, I10). *Cooperation* operates within and across TWGs and CASICs, where sectors co-design work plans, share media platforms, and run joint awareness and IPC activities – Kisumu’s routine cross-sector radio outreach and joint healthcare-waste planning with NEMA exemplify this (I7). *Competition* appears subtly in *resource contestation and prioritisation*: interviewees repeatedly noted human health absorbing “a big chunk” of funding and attention, with animal health second and environment “a distant” third, shaping whose activities move first (I7). At national level, sectors also balance agenda space (e.g. environment newly entering surveillance; fisheries seeking inclusion after limited attention in NAP I), resulting in negotiated sequences of activity roll-out rather than simultaneous coverage (I6, I9).

Outcomes to date (national and county): The most notable outcomes at the national level are (a) a fully costed NAP II (2023–2027) with an added governance objective; (b) institutionalisation of multisector TWGs; (c) expansion plans for One Health surveillance to include environment and aquaculture, beginning with mapping of contamination sources and specimen streams (wastewater, sewage) and lab capacity strengthening; and (d) incremental mainstreaming of AMR activities into existing sectoral programmes (I9). As one national focal summarised, the plan now aims “to scale… to include the environment and aquaculture” with revised One Health surveillance strategy; implementation will start from risk assessments and joint inspections by regulators (I9). At the county level**,** CASICs and costed work plans are in place in several counties, enabling tangible activities: public awareness (mass media in Kisumu; Information, Education and Communication (IEC) materials at facilities), facility AMS (Nairobi’s Mbagathi mentorship; antibiogram development), and healthcare-waste planning with environmental authorities. Yet, environmental actions are nascent: Kisumu’s environment focal cited diaper waste as the “biggest elephant in the room”, and the need to map point/non-point hotspots with the Water Resources Authority (WRA) and Government Chemist. These activities are costed but not yet activated through budget lines (I8). Resource and procurement constraints slow lab operations and stewardship implementation (I11).

“We… realised that environment plays a pivotal role because both human health and animal health are the environment,” observed a county focal, before noting the practical gap that “environment is a bit lagging behind” for lack of partners and budget (I7). At national level, environment regulators acknowledged the same gap from their side: “we didn’t… realise we were missing out… AMR is not in our [inspection] checklist”, but regulatory reviews now offer an “opportunity” to integrate AMR parameters into standards, audits and permits (I5). Fisheries similarly reported policy inclusion without operational reach under NAP I; surveillance and awareness are slated to expand under NAP II once labs are resourced (I6).

The focal action situation exhibits hierarchical coordination (statutory committees; costed national plan), layered with cooperative arrangements in TWGs and CASIC practice, and pockets of competitive dynamics over attention, budget and agenda space. Outcomes cluster where mandates and resources align (human/animal health surveillance, facility AMS, mass awareness). The environmental dimension of AMR, while formally recognised in NAP II, remains at an early stage, in practice, with regulatory integration, hotspot mapping and environmental surveillance still being set up.

Adjacent action situations

Action situation 1: Planning and design of AMR activities

Planning and design are the hinge through which national priorities, indicators and roles cascade into county practice. Actors include the NASIC Steering Committee and Secretariat, and sector regulators – Pharmacy and Poisons Board (PPB), National Environment Management Authority (NEMA), Directorate of Veterinary Services (DVS), Kenya Fishery Service (KFS), Water Resources Authority (WRA) – line ministries for health and livestock/fisheries, the National Public Health Laboratory (NPHL), quadripartite (WHO, WOAH, FAO and UNEP) and bilateral cooperation partners. Planning is done through technical working groups and structured workshops, in which templates, calendars, indicator sets and costing approaches are negotiated. With regards to the integration of environmental dimensions, one respondent described the current thrust succinctly: “workshops… to discuss progress… bringing in the environmental dimensions… what could be considered going forward” and to clarify “what should you be looking for and at what sensitivity” so that environmental surveillance can “speak to the human health and animal health” (I1). Nationally, the NASIC Secretariat coordinates day-to-day processes, while the Steering Committee sets direction and reviews progress; county liaisons feed into these cycles through CASIC templates and reporting (I9)

With regards to rules-in-use, boundary/position rules define who is in the room and when; information rules crystallise clinical indicators early; aggregation rules allow decisions to be taken in separate fora; and scope rules omit explicit environmental targets. The outcome is a plan that routinely funds clinical surveillance and AMS in human health, and to some extent animal health, while leaving environmental activities ad hoc. This sequencing was noted by a national stakeholder: “We attend AMR meetings, zoonoses discussions, and food safety meetings, but there is little integration… We need stronger coordination… rather than working in silos” (I9). Counties similarly observed that parallel meetings with overlapping participants do not automatically translate into costed environmental indicators: “Without dedicated funding and continuity in leadership, some counties struggle to operationalise their plans” (I7); county focal persons therefore push to get environmental parameters into the plan before budgets close (I11).

The planning and design action situation displays a mix of coordination modes. First, hierarchy structures the arena: NASIC/CASIC rules, secretariat procedures, and ministerial sign-off provide orchestration and set the baseline templates and calendars (I9). Second, cooperation animates TWGs and partner workshops, where sectors negotiate indicator definitions, sensitivity thresholds, and cross-sector linkages. Third, competition surfaces subtly in agenda space and budget sequencing: human health pipelines enter earliest, animal health follows, and environment competes to be specified early enough to be funded; counties also vie for partner support to underwrite planned activities (I7, I11). In practice, the mix looks like hierarchical scaffolding for order, cooperative routines for co-production and learning, and competitive prioritisation to decide what gets locked into the annual plan.

Outcomes of this action situation to date include a costed NAP II (2023–2027) that explicitly seeks environmental and aquaculture inclusion, mapped entry points for wastewater and sediment sampling, and a blueprint for standardising environmental parameters so surveillance can interoperate across the One Health spectrum (I9, I1). To shift the mode balance toward more effective hybrid mix of modes, interviewees pointed to three adjustments: publish a shared One Health planning calendar that forces joint milestones; guarantee voting seats for NEMA and WRA in NASIC/CASIC so environmental voices are present at agenda-setting nodes; and pre-specify a minimum set of environmental AMR indicators and sampling obligations, with sensitivity thresholds agreed in TWGs – so these items are hard-coded into costing and procurement from the outset (I1, I7, I9, I11).

Action situation 2: Resource allocation and capability provision

Resource allocation translates plans into capabilities. Actors span central ministries, county authorities and sector departments, development partners aligning projects to the NAP, and implementing facilities/utilities that convert budgets into staff, consumables, equipment and services. Interactions revolve around annual budget hearings, partner pipeline negotiations, and procurement planning and execution. Respondents consistently described a predictable ordering of attention and funds: human health “takes a big chunk,” animal health follows, and “environment comes in at a distant [third]” (I7). At the operational edge, a county AMS lead tied performance directly to inputs: “We want [Mbagathi] to serve as the centre of excellence… but supplies and staffing in microbiology remain a challenge” (I11). On infrastructure, the wastewater operator captured a long-standing bias in capital flows: “many resources are diverted toward clean water… wastewater is forgotten,” even though the plant “collect[s] about 80 per cent… of sewage,” and still struggles with BOD/COD [biological oxygen demand/chemical oxygen demand][4] limits because ponds are silted and algae-laden (I12).

In this action situation, choice rules embedded in budgeting and procurement systems privilege surveillance in human and animal health over environmental analytics. Information rules do not yet require antibiotic residues or AMR parameters in environmental monitoring contracts, so these lines are rarely costed ex-ante. Payoff rules (how success is assessed and rewarded) emphasise visible outputs and short reporting cycles, making one-off awareness or facility indicators more “fundable” than long-horizon investments like pre-treatment or residue testing. Scope rules seldom set explicit environmental risk-reduction targets, so there is no downstream accountability to pull these items through the budget. Aggregation rules centralise approvals in ways that favour already-institutionalised pipelines (I7, I11, I12). Together, these rules create a financing equilibrium in which clinical and veterinary tasks move first, while environmental actions wait for yet-to-materialise external support (I7, I12). Where partners are pushing to “bring [the environment] on board… and to standardise what should you be looking for and at what sensitivity”, this is beginning to alter information and choice rules, but the costing is “to be revisited”, signalling the work still to do (I1).

Resource allocation mixes hierarchy, cooperation and competition. Hierarchy dominates the formal budget cycle (laws on ceilings and procurement), giving central ministries and county authorities decisive agenda-setting power (I11). Cooperation appears when sectors and partners co-design financing for shared priorities, for example aligning AMS mentorship with lab upgrades or scheduling joint NEMA-WRA inspections with sampling resources, yet these cooperative packages are still the exception rather than the rule (I1, I11). Competition is most visible in sequencing and agenda space: sectors and counties compete to get their items specified early enough to be funded. Utilities compete with potable-water investments for scarce capital and operational expenditures, and partner projects compete on visibility and timelines

4 Biological oxygen demand (BOD) and chemical oxygen demand (COD) are the routine standards wastewater treatment plants generally strive to comply with.

(I7, I12). In practice, the mode blend looks like hierarchical scaffolding for order, selective cooperation to assemble fundable bundles, and persistent competition that decides what gets locked into the year's plan.

The current configuration reliably funds human-health surveillance and stewardship and, to a lesser extent, veterinary work. It delivers tangible AMS mentorship in selected facilities but leaves environmental surveillance, wastewater pre-treatment and residue analytics under-resourced (I7, I11, I12). The near-term consequence is incremental environmental integration and episodic pilots rather than routine practice. Interviewees pointed to actionable shifts that would rebalance rules and modes: pooled procurement of residue-testing consumables through the NPHL. Performance-based mini-grants for CASICs that deliver matched clinical-environmental datasets quarterly, targeted lines for hospital pre-treatment and joint NEMA–WRA inspections that directly connect monitoring to enforcement (I11, I12, I1). In effect, these steps rewrite information and payoff rules (what counts and gets rewarded), and use a cooperative package within a hierarchical budget frame to temper zero-sum competition, so that environmental tasks can move from ad hoc to routine.

Action situation 3: Human health – prescription, use and disposal of antimicrobials

This arena links prescribers, facility managers, retail pharmacies, county public-health departments and the Pharmacy and Poisons Board (PPB) through day-to-day prescribing/ dispensing, antimicrobial stewardship (AMS) rounds, healthcare-waste handling and regulatory inspections. Boundary/position rules assign PPB inspectors and county officers supervisory roles, while hospitals and pharmacies act as implementers with varying compliance cultures. Choice rules consist of clinical/AMS/IPC protocols and standard operating procedures for disposal; information rules specify what must be documented and reviewed, e.g. antibiograms, prescription audits, inspection findings and evidence of proper segregation/storage of pharmaceutical waste. Aggregation rules operate via facility committees and CASIC touchpoints that endorse AMS plans and corrective actions. Under tight budgets, payoff rules shape behaviour: compliant disposal, pre-treatment arrangements and laboratory workups impose visible costs, whereas the risks of non-compliance may be perceived as diffuse. Scope rules prioritise AMS/IPC outputs and inspection closure, but do not yet set explicit environmental targets for health facilities.

Out interviews point to uneven disposal compliance and capacity-dependent stewardship. A regulator underscored the disposal gap: "We conducted a study on 97 community pharmacies and found widespread non-compliance in pharmaceutical waste disposal… This is a critical issue that needs urgent regulatory action" (I4). On the provider side, stewardship is advancing via mentorship, but constrained by inputs and staffing: "We want Mbagathi to serve as the centre of excellence [for AMS] … but supplies and staffing in microbiology remain a challenge" (I11). Where inspection tools do not explicitly require AMR-relevant checks, for example, verification of hospital pre-treatment arrangements with utilities or chain-of-custody for pharmaceutical waste, leakage into general waste streams and sewers is more likely to persist (I4, I11). Likewise, when antibiograms are produced but not routinely paired with downstream environmental checks, their value for cross-sector control diminishes (I11).

Coordination in this situation also occurs through a mix of modes. Hierarchy structures oversight through PPB licensing, inspections, and post-market surveillance, and through county enforcement of facility standard operating procedures (I4). Cooperation animates AMS mentorship, clinical audit cycles and joint problem-solving between hospitals and county teams (I11). Competition surfaces as cost and attention rivalry: facilities prioritise the indicators that are audited, resourced or reputationally salient, while retail outlets weigh compliance costs against business pressures (I4, I11). Interviewees proposed rule-level fixes that braid these modes: a PPB-county "take-back" compact with scheduled collections tied to inspection rounds (hierarchy

+ cooperation), and standard memorandums of understanding between hospitals and utilities that specify pre-treatment obligations, sampling points, and joint posting of results to CASIC dashboards (hierarchy + cooperation) (I4, I11).

Tangible outcomes of this action situation include AMS mentorship and antibiogram development in selected hospitals, and strengthened PPB surveillance (I4, I11). Persistent gaps include non-compliant pharmacy disposal, inconsistent verification of hospital pre-treatment, and the absence of explicit environmental targets in routine facility performance reviews, gaps traceable to information and payoff rules that still give too little weight to environmental AMR within this action situation (I4, I11).

Action situation 4: Veterinary and aquaculture – prescription, use and disposal

This action situation connects the Directorate of Veterinary Services (DVS), veterinary practitioners and producer associations in terrestrial livestock with the Kenya Fisheries Service (KFS) and aquaculture producers. DVS anchors prudent-use and stewardship messaging along livestock value chains (I10), while KFS represents the aquatic sector in national AMR leadership – "We sit at the national steering committee" – but also acknowledges current operational limits: "The first NAP did not take… fisheries… we do not have data… we have three labs… not fully operational" (I6). Actor attributes include KFS's limited lab capacity, producers' reliance on informal advice, and weak buyer incentives for residue compliance. "Many small-scale fish farmers rely on Google or YouTube to learn how to manage diseases… Without structured training or clear regulations, the misuse of antimicrobials in aquaculture will continue" (I6). In dairy, private cost pressures collide with stewardship: "Smallholder dairy farmers struggle with withdrawal periods… Without a business case for stewardship, compliance remains weak" (I10).

Boundary/position rules place DVS and KFS at the national table, but fisheries entered later and with fewer operational footholds (I6). Choice rules are embodied in veterinary practice norms and emerging aquatic guidance; in fisheries, these are not yet backed by routine surveillance or validated protocols (I6). Information rules are thin where data are scarce – KFS highlights the absence of sector data and incomplete lab readiness (I6). Aggregation rules rely on national steering/technical working group processes for priority-setting, while producer decisions remain decentralised in farms and ponds (I6, I10). Payoff rules are pivotal: without price, market-access, or payment cues linked to prudent use of antimicrobials and withdrawal observance for dairy animals after using antimicrobials, producers rationally under-invest in stewardship (I10). Scope rules emphasise prudent use/surveillance goals, but fisheries targets will only be auditable when labs are fully functional (I6).

A hierarchical strand comes from statutory mandates (DVS, KFS) and participation in the national steering structure (I6, I10). Cooperation appears in technical engagement and anticipated co-design of surveillance roll-out as aquatic labs are equipped (I6). A competitive logic shapes day-to-day producer choices: in dairy and aquaculture, the "business case" (prices, buyer requirements) determines whether withdrawal and prudent-use practices are internalised (I10, I6).

Livestock value chains exhibit ongoing stewardship work under DVS (I10). In fisheries, KFS has institutional presence but there exist operational gaps non-availability of data and partially functioning labs (I6). Where buyer requirements are thin and residue testing rare, actors under-invest in stewardship, increasing the risk that residues move into waste streams and receiving waters (I6, I10). Near-term priorities that respondents flagged are to complete lab operationalisation and pair it with producer-facing guidance and buyer-linked checks so information and payoff rules start pulling behaviour toward routine compliance (I6, I10).

Action situation 5: Wastewater and solid-waste treatment

This action situation links wastewater utilities, NEMA and WRA, hospitals/industry, private exhausters[5] and county environment actors. The Nairobi operator underscored system centrality and constraints: "we collect about 80 per cent… of sewage," yet "we are not meeting the [NEMA] requirements" for BOD/COD because ponds are silted and algae-laden, while "many resources are diverted toward clean water… wastewater is forgotten" (I12). On monitoring content, the same respondent was clear: "I don't think it is in the schedule of NEMA for testing of the antibiotics… those are challenge issues" (I12). From the regulator side, the environment authority confirmed the instrument gap: current checklists and routine parameters do not explicitly include AMR – "not even antimicrobials"; ongoing regulatory reviews are viewed as an "opportunity" to integrate them (I5). Solid-waste streams also feature: a county environment focal identified diapers as a diffuse hotspot – "Diapers are the new form of open defecation… they contain antibiotic residues… posing a significant environmental and public health risk" (I8).

Boundary/position rules locate NEMA and WRA as permitting and oversight authorities, and the utility as a licensed operator (I12 and I5). Choice rules are embodied in permit conditions and facility obligations; at present they emphasise conventional pollutant control (BOD/COD) (I12). Information rules specify what is tested and reported; interviewees note no routine antibiotic testing in schedules (I12) and no AMR items in inspection checklists (I5). Aggregation rules operate via inspection calendars and compliance reviews; joint NEMA–WRA checks occur but are not yet institutionalised as a standing cadence (I12 and I5). Payoff rules determine the costs and consequences of compliance/non-compliance. These are further skewed by budget priorities. For example, utilities face chronic constraints of capital and operational expenditures and trade-offs that favour potable water over wastewater upgrades (I12). Scope rules set outcome targets in standards; interviewees indicate these omit AMR parameters at present (I5 and I12).

Hierarchy dominates through permits, licenses, inspection schedules, and compliance requirements (I12 and I5). Cooperation appears when regulators and operators undertake joint checks, or when hospitals, utilities and counties agree on pre-treatment and sampling routines (I12). Competition is visible in capital and operating budget prioritisation – clean water investments crowd out wastewater – and in the context of limited and constrained budgets (I12).

The system sustains compliance work on conventional parameters and identifies infrastructure bottlenecks (I12). However, antibiotics/AMR remain absent from routine testing and checklists (I12 and I5), and solid-waste pathways like diapers are weakly governed (I8). Interviewees point to a near-term window to add AMR parameters during regulatory review (I5) and to align monitoring with enforcement via more regular joint NEMA–WRA inspections and clearer pre-treatment/sampling arrangements at major sources (I12).

Action situation 6: Regulation and standards for environmental protection

Environmental regulatory processes centre on NEMA (environmental compliance) and the Water Resources Authority (WRA) (water-resource protection/licensing), interacting with regulated dischargers (hospitals/industry) and operators (e.g. the Nairobi utility/Ruai Wastewater Treatment Plant (WWTP)). Interviewees also point to the role of counties in on-the-ground enforcement interfaces, and to standards bodies in defining testing expectations. One key informant highlighted the environmental signal: "Our studies found significant antibiotic contamination in Nairobi River… Environmental surveillance for AMR is urgently needed" (I3). From the regulatory instrument side, an environmental regulator was explicit about the gap: "the issue

5 Private exhausters are privately owned vacuum-truck operators that de-sludge septic tanks/pit latrines and haul the faecal sludge to designated discharge/treatment points (e.g. a WWTP)

of AMR is not there… not even antimicrobials" in environmental inspection checklists or routine effluent tests; ongoing reviews "need revision so that we can enforce" AMR-relevant requirements (I5). An operator confirmed the routine monitoring scope: "I don't think it is in the schedule of NEMA for testing of the antibiotics… those are challenge issues" (I12). Partners stressed the need to define environmental surveillance so it "speaks to the human health and animal health" streams and to agree "what should you be looking for and at what sensitivity" (I1).

Boundary/position rules assign NEMA and WRA formal oversight roles, although WRA is not formally included in the national or county-level coordination mechanisms. WWTPs like Ruai operate under licenses/permits (I12 and I5). Choice rules live in permit conditions, Environmental Impact Assessments (EIAs) and audit requirements. At present, they emphasise conventional pollutants (BOD/COD), not antibiotics or resistant organisms (I12 and I5). Information rules specify what must be sampled/reported. Interviewees note no routine antibiotic testing and no AMR items in inspection checklists (I12 and I5). Aggregation rules organise inspections and compliance reviews and structured joint enforcement is reported but rare, not a regular mandated practice (I5 and I12). Scope rules (legal thresholds/standards) omit AMR parameters, so environmental signals are discretionary and episodic rather than obligatory (I3, I5, I12).

The action situation is hierarchical by design (laws, permits, EIAs, audits), providing order (I5, I12). Cooperation emerges in joint NEMA-WRA checks and in partner-led workshops to define environmental parameters/sensitivities (I1, I5, I12). Elements of competition appear in capital/operating budget prioritisation – "many resources are diverted toward clean water… wastewater is forgotten" (I12) – which slows the uptake of new parameters and plant upgrades.

The system sustains compliance on conventional parameters and reveals infrastructure bottlenecks (e.g. silted, algae-laden ponds at Ruai) (I12). Yet antibiotic/AMR benchmarks are absent from water/effluent standards and rarely enforced through routine instruments, so findings like the Nairobi River contamination (I3) do not automatically trigger regulatory responses upstream. Interviewees identify a near-term window: integrate AMR parameters during current regulatory review, and institute a more regular joint NEMA–WRA inspection rhythm, so that monitoring results flow into compliance actions and county dashboards and begin to hard-code AMR into everyday enforcement (I1, I3, I5, I12).

5.2 Factors affecting coordination

Coordination of antimicrobial resistance (AMR) activities in Kenya operates through a complex interplay of three distinct modes that shape collaborative effectiveness across the human health, animal health and environmental sectors. The findings reveal that hierarchical coordination provides the structural foundation through formal statutory committees (NASIC and CASICs), costed national action plans, sector-specific regulatory mandates, and institutionalised technical working groups that enable rule-bound, vertically organised implementation. Cooperative coordination emerges within and across these structures, manifested in joint work-plan development, cross-sector media campaigns, shared awareness activities, mentorship arrangements and partner mapping to leverage existing disease-control infrastructures for AMR purposes. Finally, competitive coordination operates more subtly through resource contestation and agenda prioritisation, where human health consistently absorbs the largest share of funding and attention, animal health ranks second, and environmental considerations remain "a distant third," resulting in negotiated sequences of activity roll-out rather than simultaneous sectoral coverage. These three modes – hierarchy, cooperation and competition – do not function in isolation but rather interact dynamically, with their relative influence varying across national and county levels and across different action situations, ultimately determining which AMR interventions advance and which remain constrained by mandates, resources, partnerships and political prioritisation.

We examine how three critical factors – authority, information, and resources – and their distribution are shaped by rules-in-use to influence coordination patterns and effectiveness across action situations in Kenya's AMR response.

Authority is unevenly distributed across sectors, with human health dominating agenda-setting and priority determination within NASIC and CASICs, followed by animal health, while environmental and aquaculture sectors remain peripheral. Boundary and position rules formalise this hierarchy: principal secretaries and directors from health ministries chair national committees, County Departments of Health anchor CASICs with human health focal persons serving as secretaries, and environmental regulators like NEMA and water authorities like WRA either participate marginally or remain entirely absent from coordination structures (I5, I7, I9, I11). This configuration systematically channels attention, budget allocations and implementation sequencing toward human and animal health interventions – surveillance networks, antimicrobial stewardship programmes and awareness campaigns – while environmental dimensions are acknowledged in policy documents but remain "a bit lagging behind" in practice due to weak institutional representation and limited partner engagement (I7, I9). As one county respondent noted, "environment plays a pivotal role because both human health and animal health are in the environment", yet lacks the organisational authority to claim equivalent priority (I7).

Information flows are similarly sector-skewed, reflecting choice and information rules embedded in surveillance systems, regulatory instruments and reporting protocols. The One Health AMR Surveillance System (OHAMRS) successfully integrates human and animal health data from 17 hospital laboratories and six National Veterinary Laboratories, featuring 42 dashboards that track priority pathogens, resistance patterns and testing workloads to inform national policy and WHO Global Antimicrobial Resistance and Use Surveillance System (GLASS) submissions (I9, I10). In contrast, environmental AMR data remain virtually absent because existing information rules do not require their collection: NEMA inspection checklists omit antimicrobial parameters entirely – "the issue of AMR is not there… not even antimicrobials" (I5) – wastewater permits specify conventional pollutants (BOD/COD) but not antibiotic residues (I12), and Environmental Impact Assessments rarely mandate AMR risk characterisation (I5, I12). Consequently, even when research identifies "significant antibiotic contamination in Nairobi River" or county officials recognise diapers as a diffuse source containing "antibiotic residues… posing significant environmental and public health risk", these signals do not trigger regulatory responses or enter routine surveillance dashboards because aggregation rules do not institutionalise their flow into decision-making venues (I3 and I8). Fisheries face similar issues. Kenya Fisheries Service participates in NASIC but "do[es] not have data" because laboratories equipped for residue monitoring lack reagents and operational budgets, leaving aquaculture effectively invisible in AMR planning despite its inclusion in NAP II (I6).

Resources – comprising budgets, laboratory infrastructure, skilled personnel and procurement capacity – are persistently constrained and unequally allocated. Human health "absorb[s] a big chunk" of AMR funding, animal health receives secondary attention, and environment ranks "a distant third", reflecting both historical investment patterns and the payoff rules that reward visible clinical outcomes (hospital antimicrobial stewardship, patient awareness) over less-tangible environmental monitoring and wastewater infrastructure upgrades (I7). Counties operationalise these priorities: Nairobi's CASIC focuses on facility-level stewardship mentorship and antibiogram development but struggles with procurement delays and staffing shortages (I11), while Kisumu's CASIC costs environmental activities – hotspot mapping with the Water Resources Authority, diaper-waste interventions – but cannot activate them without dedicated budget lines from national level or from development partners (I7, I8). At the wastewater treatment interface, operators report that "many resources are diverted toward clean water… wastewater is forgotten", resulting in silted, algae-laden ponds at facilities like Ruai that fail to meet NEMA discharge standards for conventional parameters, let alone hypothetical AMR benchmarks (I12). Aggregation rules compound these resource constraints. The absence of mandated joint NEMA–WRA inspection schedules or shared county-level One Health indicators spanning AMR, zoonosis, and food safety means that “the same participants rotate through parallel meetings without producing integrated action”, diluting scarce capacity across disconnected forums (I9). Finally, scope rules in national and county plans rarely articulate explicit environmental risk-reduction targets or accountability mechanisms for non-health sectors, weakening the claim on budgets and limiting downstream enforcement leverage (I1, I3, I5, I9).

Together, these interlocking configurations of authority, information, and resources – shaped by boundary, choice, information, aggregation, payoff and scope rules – explain the observed pattern: human and animal health surveillance, stewardship and awareness activities advance incrementally through institutionalised TWGs, costed work plans, operational laboratories and partner-supported implementation, while environmental integration remains nascent, characterised by policy recognition without operational reach, regulatory instruments under revision and activities costed but not yet activated (I6, I8, I9).

5.3 Outcomes

Kenya’s coordination architecture has produced clear governance and implementation gains, while exposing salient gaps at the human-animal-environment interface. On the governance side, a costed NAP II (2023–2027) anchors priorities and expands the formal structure to include the environment and aquaculture. NASIC routines (Steering Committee, Secretariat, TWGs) have become the standard venue for multisector planning and review, and CASICs are operational in multiple counties, with costed work plans and regular meetings (I7, I9). County teams report that predictable convening rules and templates have normalised AMR on administrative agendas and created a platform for joint work (I7, I11). At the same time, actors stressed that the environmental strand remains thin unless its tasks and indicators are specified early in planning and matched with funds (I1, I7, I9, I11).

A notable technical success is the Kenya One Health AMR Surveillance System (OHAMRS) (I2). Developed under NASIC leadership with grants from Fleming Fund and partners, OHAMRS integrates human and animal AMR surveillance data through a central data warehouse, using Open Interop middleware and DHIS2 for visualisation (Chuchu et al., 2024). Currently, 17 human surveillance laboratories and six national veterinary laboratories feed surveillance data into the system and provides dashboards (including priority pathogen views) for resistance trends, geospatial mapping and reporting – supporting national/county decision-making and GLASS submissions. Major achievements include customisable dashboards for resistance patterns, data-quality assessment and automated GLASS reporting; identified gaps include limited antimicrobial use/consumption data, incomplete geographic representativeness and absence of environmental data, with plans to expand sites and incorporate the environmental sector (Chuchu et al., 2024).

Respondents reported visible progress in selected hospitals through mentorship and AMS work, with some facilities positioned to serve as county centres of excellence. However, these gains are tempered by recurrent bottlenecks in staffing and supplies that slow diffusion and continuity (I11). In the retail space, regulators emphasised that disposal compliance remains uneven across community pharmacies, signalling a persistent implementation gap. Together, these patterns suggest inspection tools and performance reviews still privilege clinical outputs, while explicit environmental targets for facilities and pharmacies are not yet embedded (I4, I11).

In livestock value chains, DVS continues to drive prudent-use efforts, whereas the fisheries strand is only now catching up operationally. KFS participates in national coordination but lacks routine sectoral data, and laboratory capacity remains only partially operational due to reagent and method constraints (I6). In dairy, weak financial and market incentives for observing withdrawal periods continue to undermine stewardship. The net effect is a combination of payoff and information gaps that leaves residue risks unevenly managed along animal and aquatic value chains (I6, I10).

In the environmental domain, regulators and operators acknowledged a systemic blind spot in wastewater and solid-waste management. The Nairobi utility, despite handling the bulk of sewered wastewater, faces infrastructure constraints that limit compliance on conventional parameters, and investment priorities tend to favour potable water over wastewater upgrades (I12). Antibiotics are not part of routine effluent testing schedules, and environmental inspection checklists do not currently include AMR-relevant items, constraining enforcement leverage (I5, I12). Counties additionally identified diffuse solid-waste hotspots – such as diaper streams carrying pharmaceutical residues – that sit outside standard AMR instruments (I8). Where joint NEMA–WRA actions have been undertaken, coordination improved, but these collaborations are episodic rather than institutionalised, limiting their system-wide effect (I5, I12).

5.4 Potential solutions

Despite the formidable challenges revealed in the action situation analysis, Kenya's AMR response demonstrates significant institutional capacity and presents clear opportunities for strengthening environmental integration through strategic modifications to rules-in-use. The analysis across six action situations – NAP implementation, planning and design, surveillance, antimicrobial use and stewardship, wastewater and solid-waste treatment, and regulation and standards – reveals distinct rule configurations that either enable or constrain coordination effectiveness. Table 2 synthesises these findings, mapping the dominant rules-in-use operating within each action situation to corresponding solution pathways that address identified gaps and leverage existing institutional strengths.

Table 2: Rules-in-use and corresponding solutions across AMR action situations

Action situation	Dominant rules-in-use	Solutions	Actors
1. NAP-AMR implementation	*Boundary rules*: Environmental sector marginal *Payoff rules*: *Aggregation rules:* Prioritise human health; no environmental technical working group	- Formalise NEMA/WRA in NASIC - Establish environmental technical working group - Ring-fence environmental budget	NASIC, NEMA, WRA, Counties, Treasury
2. Planning and design	*Choice rules*: Health templates dominate *Information rules*: No environmental baselines *Scope rules*: Vague environmental targets	- Mandate joint planning workshops - Commission baseline assessments - Define explicit environmental indicators	NASIC, NEMA, WRA, KFS, partners
3. Surveillance	*Boundary rules*: OHAMRS excludes environment *Information rules*: No environmental protocols *Aggregation rules*: Episodic signals	- Expand OHAMRS with environmental module - Develop surveillance guidelines - Enrol environmental labs	NPHL, NEMA, WRA, counties

Action situation	Dominant rules-in-use	Solutions	Actors
4. Antimicrobial stewardship	*Human health: information rules:* Stewardship programmes track consumption/prescribing but lack explicit environmental targets for disposal. *Payoff rules:* Facilities gain accreditation benefits but no incentives for pre-treatment investment. *Choice rules:* Pharmacy disposal compliance is uneven. *Veterinary (livestock/dairy): information rules:* DVS implements prudent-use guidance in priority value chains but monitoring is limited. *Payoff rules:* Weak financial and market incentives for observing withdrawal periods in dairy; compliance costly without buyer-linked checks. *Choice rules:* Farm biosecurity practices variable across value chains. *Aquaculture/fisheries: information rules:* No consumption monitoring where "buyer requirements thin, residue testing rare". *Payoff rules:* No market incentives for producers to invest in stewardship. *Choice Rules:* KFS labs equipped but non-functional due to reagent/budget gaps.	*Human health:* - Enforce pharmacy disposal compliance. - Mandate hospital pre-treatment systems. Integrate environmental targets into AMS performance metrics. *Veterinary (livestock/dairy)*: - Strengthen residue monitoring and withdrawal period enforcement. - Integrate buyer-linked incentives and residue testing in dairy value chains. - Expand DVS prudent-use guidance with farmer training programmes. *Aquaculture/fisheries:* - Operationalise KFS labs with dedicated reagent budgets. - Develop aquaculture stewardship guidelines linked to market access and export certification. - Integrate aquaculture AMU data into national surveillance.	PPB, hospitals, pharmacies, livestock farmers, KFS, DVS, producers, counties
5. Wastewater treatment	*Choice rules*: BOD/COD only in permits *Information rules*: No AMR in checklists *Payoff rules*: Water over wastewater	- Revise discharge standards - Institute joint inspections - Establish pre-treatment requirements	NEMA, WRA, utilities, counties
6. Regulation and standards	*Boundary rules*: AMR not in mandates *Choice rules*: EIA not sensitised. *Scope rules*: No AMR benchmarks	- Integrate AMR in NEMA plan - Revise EIA regulations - Develop AMR water standards	NEMA, WRA, KEBS, EIA professionals

Source: Authors

As Table 2 illustrates, coordination gaps arise from misalignments between rules-in-use and One Health integration requirements. The solution pathways emphasise six dimensions of rule modification: (1) representation and authority, (2) data requirements and information flows, (3) joint protocols and aggregation mechanisms, (4) budgeting and resource allocation, (5) targets and accountability, and (6) capacity building and behavioural change.

Six dimensions of rule modification

1. *Representation and authority*: Formalising NEMA and WRA participation addresses boundary-rule gaps by ensuring environmental regulators have decision-making seats. County-level implementation benefits from designating environment officers as CASIC co-chairs, signalling priority and attracting partner attention.

2. *Data requirements and information flows*: Expanding OHAMRS to environmental matrices and revising regulatory instruments to mandate AMR parameter collection transforms environmental data from discretionary outputs into obligatory inputs, creating feedback loops that inform planning and trigger regulatory responses.

3. *Joint protocols and aggregation mechanisms*: Institutionalising regular joint NEMA–WRA county inspections and shared dashboards converts episodic cooperation into routine coordination, reducing transaction costs and enhancing accountability across sectors.

4. *Budgeting and resource allocation*: Ring-fencing environmental AMR allocations and securing dedicated line items prevents environmental activities from being deferred due to budget competition, creating predictable resource flows that justify sector engagement.

5. *Targets and accountability*: Defining explicit environmental outcome indicators and embedding them in M&E frameworks enables performance tracking and facilitates advocacy by making environmental contributions visible and measurable.

6. *Capacity building and behavioural change*: Training EIA practitioners, sensitising operators, and operationalising stewardship addresses human and organisational dimensions. Leveraging existing training platforms enhances uptake and reduces implementation costs.

6 Discussion

Kenya’s AMR governance presents a paradox consisting of sophisticated formal architecture – NASIC, CASICs, technical working groups and OHAMRS, yet shallow environmental integration, despite explicit commitments in NAP II. This section applies the analytical framework (Section 2) to explain why authority asymmetries, information gaps and resource constraints persist in weakening human–animal–environment interlinkages.

The polycentric governance lens reveals multiple overlapping decision centres with uneven functional interdependence (E. Ostrom et al., 1961). The NAAS perspective (McGinnis, 2011) directs attention to feedback loops: outcomes in one action situation should influence adjacent situations. Our results show weak environmental feedback loops. Signals from wastewater monitoring – Ruai WWTP infrastructure constraints (I12), Nairobi River contamination (I3), diaper waste hotspots (I8) – do not travel upstream to reset planning or budget priorities. Conversely, human–animal health exhibits tight loops: OHAMRS surveillance data directly inform NASIC technical working group reviews, stewardship guidelines and facility mentorship (I2, I9, I11). This reflects aligned authority, information and resources in health sectors (Koontz & Garrick, 2019), absent in environmental domains.

6.1 Rules-in-use structuring asymmetric coordination

Boundary and position rules concentrate agenda-setting in health sectors: the Ministry of Health chairs NASIC, while county-level health departments anchor CASICs; NEMA participates without voting authority, and the WRA is often absent (I5, I7, I9, I11). This produces asymmetric polycentric governance, in which multiple centres exist but exercise unequal influence (Pahl-Wostl, 2019a). Choice and information rules exclude AMR parameters from environmental instruments: wastewater permits specify BOD/COD not antibiotics; NEMA inspections omit antimicrobials; EIAs lack AMR risk requirements (I5, I12). Aggregation rules enable parallel tracks – AMR, zoonosis, food safety – fragmenting capacity: “the same participants rotate through meetings without integrated action” (I9). Payoff rules reward clinical outputs, while environmental investments compete with higher priorities: wastewater is “forgotten” as resources favour potable water (I12). Scope rules omit environmental accountability: there are no targets for hospital pre-treatment coverage, WWTP residue testing or river surveillance frequency (I1, I3, I5, I9).

The authority–information–resources (AIR) asymmetries in Kenya’s AMR governance mirror patterns observed in other polycentric systems managing common-pool resources. Mudaliar (2023), in her study of Tanzania’s Lake Victoria fisheries (another polycentric system addressing collective action challenges), reveals parallel dynamics. In Tanzania, constitutional-choice rules created overlaps among central government, local government, and beach-management units (BMUs) to enable co-management, yet authority was concentrated in the Ministry of Fisheries, while local government and beach-management units remained marginalised: “BMUs have to take permission from local authorities for everything, but they are left out of decision-making” (Mudaliar, 2023 p. 6). Information asymmetries were equally pronounced: central government withheld data from local government due to perceptions that lower levels facilitated illegal fishing, creating distrust that prevented cooperation: “cross-level forums for information-sharing are absent” despite constitutional rules mandating collaboration (Mudaliar, 2023 p. 7). Resource scarcity reinforced these asymmetries, with BMUs collecting licensing revenue but receiving only 25% back, leaving them “just existing, doing nothing” (Mudaliar, 2023 p. 7). Most critically, Mudaliar (2023) demonstrates that these AIR asymmetries interact dynamically: central government’s authority enabled it to withhold information and resources from local government, the resulting resource scarcity drove local government corruption, which validated central government’s distrust and justified further information withholding – creating self-reinforcing cycles that undermined polycentric functionality. Kenya’s AMR governance exhibits identical patterns: health-sector authority structures information rules that exclude environmental parameters, absence of environmental data prevents environmental actors from demonstrating competence and claiming resources, resource constraints reinforce perceptions of environmental inadequacy, justifying continued exclusion from authority and information flows. Both cases illustrate that constitutional-choice rules creating formal overlaps are insufficient for functional polycentricity when AIR distributions remain fundamentally asymmetric and mutually reinforcing across governance levels.

The AIR framework (Koontz & Garrick, 2019) demonstrates stark sectoral asymmetries. Authority concentrates in health through chairmanships, secretariat functions and partner liaison roles (I7, I9, I11). Environment officers lack mandates, time allocations or administrative authority for AMR: “lagging behind without strong partners” (I7). Information flows diverge: OHAMRS integrates 17 human and six veterinary labs with near-real-time data feeding dashboards and decisions (I2; Chuchu et al., 2024), while environmental data remain episodic research outputs, disconnected from surveillance systems, with no protocols for environmental matrices, sampling frequencies, or reporting formats (I1, I3, I5). Resources show greatest disparities: human health absorbs a “big chunk”, animal health is secondary, while environment comes a “distant third” (I7). Kenya Fisheries Service (KFS) labs are “equipped but not functioning” due to reagent gaps

(I6); wastewater upgrades are perpetually deferred (I12); county environmental activities are "costed but not activated" due to absent budget lines (I7, I8).

6.2 Coordination modes and hybrid governance deficits

Kenya's AMR governance combines hierarchical, network and competitive modes (Pahl-Wostl, 2019b). Hierarchical structures provide order through NASIC/CASIC mandates and regulatory powers, but embed path dependencies favouring sectors with established positions. Network modes enable cooperative work plan co-design and joint awareness campaigns (I7, I9, I11), but rely on voluntary participation vulnerable to resource constraints and personnel turnover. Competition surfaces in resource allocation and agenda sequencing, producing "negotiated sequences", whereby health activities advance first while environmental activities await external support (I7, I9). Effective hybrid governance requires meta-governance – reflexive learning to balance modes synergistically (Pahl-Wostl, 2019b). Kenya exhibits partial meta-governance through NAP reviews identifying gaps, but has not yet translated learning into fundamental rule changes that would realign authority, information and resources across sectors.

6.3 Enablers and barriers to governing interlinkages

Enablers of coordination include predictable NASIC/CASIC platforms institutionalising cross-sector interaction (I7, I9, I11); OHAMRS standardising human–animal health surveillance (I2); emerging stewardship norms creating shared expectations (I10, I11); partner support providing resources and convening power (I1, I9); and localised polycentric complementarities whereby counties pair interventions strategically (I7, I11). Barriers, by contrast, are structural in nature: boundary rules excluding environmental authority; information rules omitting environmental AMR parameters from permits, EIAs and inspections; payoff rules creating disincentives for environmental investment; aggregation rules enabling parallel tracks; scope rules lacking environmental accountability; and weak value-chain incentives in aquaculture, dairy and pharmacy disposal (I4, I6, I8, I10, I12). These mutually reinforcing barriers create "leaky interlinkages": pharmaceutical waste reaches wastewater systems, utilities don't test residues, contamination signals fail to trigger upstream corrections (I3, I8, I12).

6.4 Options for effective environmental integration

The framework identifies rule-focused interventions to realign coordination:

Boundary/position rules: mandate NEMA/WRA voting seats in NASIC, designate environment officers as CASIC co-chairs (I1, I5, I7, I9).

Information rules: embed AMR parameters in effluent permits, EIAs, inspection checklists; standardise environmental surveillance protocols compatible with OHAMRS (I1, I3, I5, I12).

Aggregation rules: institutionalise quarterly joint NEMA–WRA county inspections; adopt shared One Health planning calendars forcing synthesis (I5, I9, I12).

Payoff/resource rules: ring-fence environmental AMR budgets; finance hospital pre-treatment and WWTP upgrades; operationalise KFS labs; integrate buyer-linked incentives in aquaculture/dairy (I6, I7, I8, I10, I11, I12).

Scope rules: define explicit environmental indicators – hospital pre-treatment coverage, WWTP testing frequency, river surveillance – in monitoring and evaluation frameworks with quarterly accountability (I1, I3, I5, I9).

Kenya's AMR governance exhibits partial coordination: sophisticated architecture yet weak environmental integration. The analytical tools of polycentric governance approach, the IAD framework, and the concepts of NAAS and AIR explain this pattern not as institutional absence but as specific rule configurations that privilege health-sector actors, actions and outcomes. Boundary rules concentrate authority; information rules exclude environmental parameters; aggregation rules fragment action; payoff rules misalign incentives; scope rules omit accountability. These rules attenuate environmental feedback loops while enabling human–animal health advancement. Effective One Health governance requires not merely inviting environmental actors to meetings but fundamentally reconfiguring rules to institutionalise environmental authority, mandate environmental data, pool regulatory capacity through joint protocols, ring-fence environmental budgets, and establish environmental accountability – transforming formal inclusion into operational integration.

7 Conclusion and way forward

Kenya's coordination for AMR mitigation is partly effective but uneven: formal platforms (NASIC/CASIC) and emerging stewardship routines enable cross-sector interaction, yet authority asymmetries, missing environmental information in core rules, and thin resources prevent strong interlinkages among human, animal and environmental domains. Effective integration of the environmental dimension requires targeted rule redesign – mandated representation of not just environment but water authorities, embedded residue/AMR parameters in permits, EIAs and inspections, institutionalised NEMA-WRA joint actions, dedicated financing for pre-treatment and environmental surveillance, and value-chain incentives – so that environmental signals reliably inform planning, budgeting and enforcement.

This study advances AMR governance analysis by operationalising a polycentric lens (IAD plus NAAS) to map how Kenya's focal and adjacent action situations actually function and connect, and by tying those connections to the seven rules-in-use and the authority–information–resources (AIR) triad. The results explain why a system with many committees can still underperform: boundary/position rules concentrate agenda-setting in health sectors, marginalising environmental actors despite their formal participation; information rules omit environmental indicators from the instruments that matter (permits, EIAs, inspection tools); aggregation rules allow parallel tracks to proceed without synthesis; payoff rules make compliant disposal and pre-treatment costlier than visible clinical outputs, while resource scarcity reinforces perceptions of environmental inadequacy; and scope rules rarely set explicit environmental targets. These rule configurations attenuate feedback loops from wastewater plants and rivers back to planning and resource allocation, leaving environmental risks weakly governed, despite regular meetings and reporting. Conversely, where counties deliberately paired public-health surveillance with checks at effluent points, coordination improved – illustrating how even modest adjustments that strengthen inter-situation linkages can yield outsized gains.

A key way forward for research on antimicrobial resistance (AMR) and One Health governance is to empirically unpack how rules-in-use structure interdependencies among Kenya's AMR action situations – and to locate environmental gaps within that network. Two research avenues are especially promising:

(i) prospective evaluations of "information-rule" reforms (embedding residue/AMR parameters in permits and inspections) to test whether they activate upstream feedback into planning and budgets; and

(ii) comparative cost-effectiveness studies of coordination interventions (e.g. joint inspections, hospital pre-treatment, value-chain incentives) across counties, to identify scalable mixes that deliver measurable environmental risk reduction.

7.1 Policy recommendations

The most promising pathway is to “rewire the rules” that organise interactions across action situations. First, fix boundary/position rules by granting environment and water agencies voting roles and routine tasks in NASIC/CASIC through formal amendments to NASIC/CASIC terms of reference designating NEMA and WRA as co-equal members with agenda-setting authority, and by specifying joint responsibilities in surveillance and enforcement. Second, hard-code environmental *information rules* – antibiotic residues and AMR parameters – into effluent permits, EIAs and inspection checklists, and link hospital antibiograms to downstream sampling and shared repositories through NEMA regulatory reviews and expansion of OHAMRS to include environmental surveillance modules. Third, upgrade aggregation rules by institutionalising NEMA–WRA joint inspections with regular mandatory schedules and standardised protocols and adopting a shared planning calendar that forces synthesis across AMR, zoonosis and food-safety tracks. Fourth, align payoff rules/resources through dedicated budget lines for environmental AMR actions (pre-treatment, WWTP upgrades, residue testing) with ring-fenced allocations in NAP budgets at national and county levels and buyer-linked incentives in aquaculture and dairy plus strengthened residue monitoring and withdrawal period enforcement in livestock value chains. Finally, adopt scope rules that set explicit and realistic environmental risk-reduction targets (e.g. 50% hospital pre-treatment coverage, regular river surveillance at priority sites and periodic residue testing at WWTPs) and tie them to NASIC/CASIC performance reviews. These changes do not require new institutions; they align authority, information and resources so that evidence moves with the same regularity as meetings already do.

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Annex

Annex 1: List of key informants for interviews and stakeholders engaged

Interview No	Affiliation/Organisation	Level	Government/Academia/ Civil Society/Multilateral
1	Environment	Global	Multilateral
2	Human health	National	Government
3	Environment	National	Government
4	Human health	National	Government
5	Environment	National	Government
6	Animal health (fisheries)	National	Government
7	Human health	County	Government
8	Environment	County	Government
9	Human health	National	Government
10	Animal health	National	Government
11	Human health	County	Government
12	Environment	County	Government
Stakeholder Meeting	Sector		
1	Animal health	Global	Multilateral (WOAH)
2	Animal health	National	Academia (KALRO)
3	Human health	Regional	Civil Society (ReACT Africa)