Optimising AMR surveillance in animal health
A Case Study Review

February 2026

Contents

Figures

Tables

Boxes

Authored by **Timothy Worth**, **Stanley Fenwick**, **Daniel Whitaker**, **Toby Leslie**, **Adrienne Chattoe-Brown** and **Manisha Bista** at Mott MacDonald, the Fleming Fund Management Agent.

With support from the **Fleming Fund grantees**:

Technical Assistance for Data and Evidence Use Africa (TADE Africa)	**Moctar Mouiche** (ASLM) **Ntombi Nkonde** (UNZA)
Technical Assistance for Data and Evidence Use Asia (TADEU Asia)	**Jung-Seok Lee** (IVI) **Deepak C. Bajracharya** (GTA)
Zambia Country grantee	**Kaunda Kaunda** (CIDRZ)
Nepal Country grantee	**Ritu Amatya** (FHI360)

Acronyms

AMR	Antimicrobial resistance
AMS	Antimicrobial stewardship
AMU	Antimicrobial use
AST	Antimicrobial Susceptibility Testing (AST) – a laboratory method used to determine the effectiveness of antibiotics against bacteria.
ASLM	African Society for Laboratory Medicine
CHAZ	Churches Association of Zambia
CVRI	Central Veterinary Research Institute (Zambia)
CVL	Central Veterinary Laboratory (Nepal)
DVS	Department of Veterinary Services
GDP	Gross Domestic Product
GTA	Group for Technical Assistance (Nepal)
IPC	Infection Prevention Control
IVI	International Vaccine Institute
KII	Key Informant Interviews
LMIC	Low- and middle-income country
NRL	National Reference Laboratory
UTI	Urinary Tract Infection
VfM	Value for Money
WOAH	World Organisation for Animal Health
ZNPHI	Zambia National Public Health Institute

Executive Summary

AMR is an escalating One Health threat with major implications for human health and animal production. Surveillance data is essential to monitor trends, guide antimicrobial stewardship (AMS), and inform policy and investment decisions. However, animal health AMR surveillance in low- and middle-income countries (LMICs) is resource-intensive, and sustainability beyond donor support remains a central challenge.

This report, prepared as the Fleming Fund concludes in 2026, reviews the effectiveness, cost-efficiency, and sustainability of different animal health AMR surveillance strategies, including farm-based, abattoir, opportunistic, and wastewater sampling. We have explored these questions through case studies carried out in Zambia and Nepal.

Methodology

The review compares surveillance methodologies using a mixed methods approach: a targeted literature review; analysis of Fleming Fund programme data and costing studies from the Data and Evidence Use Regional Grants (TADE Africa and TADEU Asia[2]); field visits and stakeholder engagement in Zambia and Nepal in 2025 to observe implementation and inform modelling assumptions. Details of the methodology are in annex 1.1 in the separate appendices.

Case Study Review

Zambia: Established foundations and baseline data, but high ongoing costs

In Zambia, the Fleming Fund supported farm-based active surveillance to build bacteriology capacity, develop protocols, and generate traceable baseline AMR/AMU data. Key achievements include strengthened bacteriology capacity across five laboratories and support for testing 4,758 samples (2021–2024)[3], enabling of regular reporting and submission of animal health AMR data to the World Organisation for Animal Health (WOAH), AMS integration into veterinary training and development of treatment guidance.

However, field observation and stakeholder discussions highlighted a major sustainability risk for animal health surveillance: farm-based active surveillance sampling is expensive, logistically demanding, labour-intensive, and creates irregular ‘boom and bust’ sampling cycles at the laboratory level that can drive deskilling and consumable wastage. Cost analysis across selected Zambian sites shows an average cost per sample of £569 when set-up investments are included, reducing to £286 per sample for estimated ongoing costs. This is comparatively high and difficult to prioritise within government financing. The report also notes that the Fleming Fund contributed a substantial share of the estimated ongoing cost base (~37%), making continuation of dedicated farm-based sampling more challenging once external funding ends.

Nepal: Adaptive, lower-cost sampling, stronger One Health integration and sustainability

Nepal was selected as a contrasting case study because it had successfully evolved animal health surveillance within an integrated One Health system. The Fleming Fund supported testing of 22,504 samples (2018–2025) across seven laboratories. Evidence generated has been used to support concrete policy outcomes, including a ban on Colistin use in animal feeds, a government-endorsed essential veterinary medicines list, and an AMS action plan spanning multiple production systems.

Nepal transitioned from primarily farm-based sampling to a more cost-efficient slaughter site-based approach, complemented by environmental sampling and integrated surveillance across ministries. Surveillance at slaughter sites in urban centres reduces travel costs, enabling efficient collection of large numbers of samples with strong relevance to the food safety agenda. However, it reduces farm-level traceability and has a limited ability to collect AMU data from farmers. Costing data from Nepal’s selected sites are substantially lower, £126 per sample, and have a high level of government financing, which signals stronger prospects for sustainability.

Comparative model: Cost-efficient strategies could maintain surveillance outputs

Using the Chipata site in Zambia as a baseline for the costs of ongoing farm-based surveillance, we have modelled alternative approaches intended to maintain similar annual sample throughput under reduced budgets. Results suggest that compared with farm-based ongoing costs (reported as £280 per sample), alternative strategies could reduce costs while supporting a steadier sample flow: opportunistic sampling integrated into routine activities (~£184 per sample), abattoir sampling (~£165), and wastewater surveillance (~£160). These approaches trade some traceability for affordability, frequency, and scalability, key determinants of sustainability in LMIC contexts.

1. **African Society for Laboratory Science (ASLM).**
2. **International Vaccine Institute (IVI).**
3. Sample data collected by TADE Africa from the selected laboratories.

Recommendations

This study has identified the potential cost-efficiency of alternative strategies, especially sample collection through abattoirs or wastewater sampling. The modelled costs of the alternative strategies highlight that the loss of Fleming Fund budget (~37%) could be accounted for by an optimisation of the animal health surveillance strategy. This study has identified four key recommendations for future programmes seeking to strengthen AMR surveillance in the animal health sector:

1) Avoid silos

Dedicated farm-based AMR sampling can build capacity and provide robust baseline estimates, but it is less cost-efficient and often misaligned with routine veterinary priorities. Embedding AMR sampling within existing programmes (vaccination campaigns, disease surveillance, movement controls, food safety/meat inspection) improves efficiency, feasibility and buy-in by breaking down silos.

2) Scan and target surveillance strategies

A blended scan and target surveillance model could strengthen coverage, integration, and long- term sustainability. Cost-efficient sampling strategies (opportunistic, abattoir, and wastewater) should be used to scan for emerging resistance trends and maintain routine laboratory throughput, with farm-based sampling reserved for targeted follow-up when the data warrants further investigation. A pilot study is required to validate operational design, quantify any biases, and estimate the full costs to inform policymakers.

3) Continue to adapt and refine strategies

The contrast between Nepal's adaptive model and Zambia's continued reliance on farm-based surveillance highlights the need for periodic reassessment to sustain data utility within constrained budgets.

4) Leverage the opportunities left by the Fleming Fund

The Fleming Fund leaves a strong foundation on which to build. Across participating countries, the Fund has raised awareness of AMR, established a robust baseline data set, strengthened laboratory systems, and leaves a skilled workforce capable of sustaining surveillance activities.

This creates a clear opportunity to consolidate and extend animal health AMR surveillance as an integral part of national One Health systems. Targeted investments could build on existing infrastructure and capacity, enabling cost-efficient sample collection aligned with government priorities and budgets. Maintaining and strengthening these systems will ensure that high-quality animal health AMR data continues to be collected and used to inform policy, planning, and investment decisions.

1. Introduction

AMR refers to the ability of microorganisms, such as bacteria and viruses, to resist the effects of medications used to treat them. This resistance complicates treatment plans, leading to longer hospital stays, higher medical costs, and increased morbidity and mortality. When previously treatable infections develop drug resistance, the impact is costly and deadly, with the potential to disrupt human, animal and food production systems. The current economic and health impact is assessed as:

- 1.14 million deaths in 2021 because of drug-resistant infections, with a further 4.71 million deaths associated with AMR[4].
- LMICs have the highest rates of AMR attributable deaths, with sub-Saharan Africa (18.5 per 100,000 people) and South Asia (18.1 per 100,000 people) almost twice the rate in high-income countries (11.4 per 100,000 people)[4].
- Across 34 OECD countries, the cost of complications resulting from resistant infections exceeds $28.9 billion per year, and reduced workforce participation and productivity costs a further $36.9 billion per year to their collective economies[5].

The future impact has been projected as:

- 1.91 million deaths because of AMR and 8.22 million deaths associated with AMR globally by 2050[4], with a cumulative 40 million deaths between 2025–2040[6], and the highest burden in LMICs.
- $66 billion per year of additional direct healthcare costs by 2050, which could rise to $159 billion if current resistance trends continue[7].
- A 3.8% annual loss of global GDP, with LMICs losing 4.4% annually by 2050 due to AMR[8].

4. Naghavi, M. et al. (2024), '**Global burden of bacterial antimicrobial resistance 1990-2021: a systematic analysis with forecasts to 2050**', *The Lancet*, 404(10459), 1199–1226.
5. OECD (2023), '**Embracing a One Health Framework to Fight Antimicrobial Resistance**', *OECD Health Policy Studies*, OECD Publishing, Paris.
6. Naddaf M. (2024), '**40 million deaths by 2050: toll of drug-resistant infections to rise by 70%**', *Nature*, 633:747-8.
7. McDonnell A. et al. (2024), '**Forecasting the Fallout from AMR: Economic Impacts of Antimicrobial Resistance in Humans. A report from the EcoAMR series'**, *A report from the EcoAMR series*, Paris, CGD.
8. Jonas, O. et al (2017), '**Drug-resistant infections: a threat to our economic future, Global Antimicrobial Resistance Initiative**', Washington, D.C.

Tackling AMR requires a multifaceted approach, including promoting AMS, bolstering infection prevention and control (IPC), improving equitable access to antibiotics, investing in new antimicrobials and vaccines, and enhancing clinical diagnostics and global surveillance networks. The Global Action Plan calls for enhanced surveillance of AMR, which results from improved access to diagnosis and antibiotic susceptibility testing in suspected bacterial infections. The data and evidence produced by these diagnostic and surveillance activities are key to addressing this constantly evolving threat[9].

As many of the bacterial species of concern can spread freely between animals, the environment and humans, a One Health approach is required. One Health is a multisectoral, multidisciplinary approach that recognises the interconnected and interdependent nature of the health of humans, domestic and wild animals, plants, and the wider environment[10].

To address this complex issue, the UK government invested ~£300 million through the Fleming Fund between 2016–2026. The objective was to improve the ability of LMICs to diagnose drug-resistant infections, and to collect, analyse and leverage surveillance data to improve practice, policymaking and direct investment to address AMR.

The Fleming Fund is a One Health programme that promotes an integrated and unified approach to deliver effective and sustainable health outcomes. It has invested in human, animal, environment and food laboratories. It has promoted data collection, sharing, analysis, and policymaking through joint action between human, animal, agriculture, and environment government ministries to develop national One Health AMR surveillance systems.

AMR surveillance is often seen as resource-intensive, requiring investments in infrastructure, equipment, training and laboratory consumables, costs that challenge limited budgets in LMICs. This review examines animal health surveillance strategies through the lens of Value for Money (VfM) and sustainability. Using case studies from two different countries, it assesses the AMR surveillance strategies employed in the animal health sector. The review explores ways to improve efficiency, effectiveness, strengthen One Health integration, and support sustainability by comparing alternative surveillance strategies. Ultimately, this research evaluates the costs and benefits of animal health surveillance strategies to provide governments with evidence for planning and budgeting.

1.1 AMR surveillance in the animal health sector

1.1.1 The importance of animal health surveillance

Antibiotic use is common in the animal health sector, which accounts for a majority of global consumption and is expected to continue to grow[11]. By some estimates, more than 80% of global antibiotic consumption is in the animal health sector. There are several drivers of antibiotic use (and consequently, AMR) in animals, including lack of regulation, low awareness, poor animal husbandry practices, and lack of investment in biosecurity and sanitation. These conditions lead to an overreliance on antibiotics in agriculture, which will increase resistant bacteria and is projected to cause an 11% loss of livestock production by 2050[12]. This will also lead to more human infections through the food supply chain and the environment. Therefore, an effective AMR surveillance system must take a One Health approach, in which animal health AMR surveillance is a key component, providing data to build awareness and guide improved regulation, AMS, and improvements in biosecurity and sanitation.

1.1.2 The importance of livestock

Livestock production is central to food security and the economies of many LMICs, including the countries chosen as our case studies. In Nepal, over 52% of the population relies on agriculture and livestock for employment and income, with livestock contributing to approximately 7% of the national GDP. Similarly, in Zambia, ~50% of the population relies on agriculture for income, with livestock accounting for 42% of agricultural output and contributing 8.2% to national GDP. Although the GDP figures are below 10%, this underestimates the importance of the sector to both Nepal and Zambia for food security and poverty alleviation[13,14].

9. WHO (2015), '**Global action plan on antimicrobial resistance**', Geneva.
10. WHO (2025), '**One Health**'.
11. Mulchandani, R. et al (2023), '**Global trends in antimicrobial use in food-producing animals: 2020 to 2030**'. *PLOS Global Public Health*, 3(2), e0001305.
12. Jonas O. et al (2017), '**Drug-resistant infections: A threat to our economic future**', *World Bank Group*.
13. Acharya KP and Wilson RT (2019) '**Antimicrobial Resistance in Nepal**'. *Frontier Medicine*, 6:105.
14. **Ministry of Fisheries and Livestock (2020) National Livestock Development Policy**.

In Nepal, the Government has focused on self-sufficiency and improving productivity through breed enhancement, disease control, and infrastructure development, and the sector has rapidly modernised away from traditional subsistence farming but has virtually no exports[15]. In Zambia, the sector is viewed as having significant potential for exports because of its vast savannah grazing areas and other resources for livestock production[16]. In both countries, as with many comparable LMICs, there has been increasing use of antimicrobials to achieve faster animal growth rates, prevent diseases and increase profitability. However, there has been a relative lack of investment in surveillance, biosecurity and husbandry practices, which can lead to increased AMR in the animal health sector.

The critically important role that livestock production plays in LMICs, and its growing importance for food security and poverty reduction, means that it is politically challenging to introduce what are seen as additional costs and restrictions on practices. This is especially true when animal health regulatory institutions are relatively weak compared to human health, and the AMR bacteria that affect humans often do not cause disease or poor productivity in livestock. While it can be argued that animals are a source of AMR bacteria for humans through the food chain and the environment, control of animal diseases is a priority for veterinary services, which means that resources for AMR surveillance and control in this sector are consequently (and rationally) low.

Box 1: Animal health in the Fleming Fund

Recognising the role of the animal health sector in One Health, the Fleming Fund made it a core workstream. The initial phase of the Fleming Fund concentrated on strengthening national veterinary reference laboratories, and – in some countries – provincial laboratories, to strengthen national systems. Support included upgrading infrastructure, provision of equipment and consumables and training and mentorship for relevant staff. NRLs joined external quality assurance programmes funded by the programme, improving proficiency and operating procedures. As a result, laboratories across the Fleming Fund have advanced their competencies in bacteriology diagnostics, including the identification of a wider range of pathogens, improved AST, and the investigation of AMR transmission mechanisms.

The second phase of the Fleming Fund placed greater emphasis on using data to inform national guidelines and policies, particularly around practitioner engagement and AMS, to promote rational sale and use of antibiotics. Many countries have developed standard treatment guidelines for multiple livestock species and essential medicine lists to support legal importation and manufacture of veterinary antibiotics.

The Fleming Fund has supported active surveillance for AMR in animals, which is a proactive and deliberate approach to sample collection according to a protocol. This contrasts with passive surveillance, where samples are collected from clinically affected animals without additional efforts, yielding a different set of results because of a systematic sampling bias towards sick animals. Active surveillance has enabled the establishment of a robust and traceable baseline of data that is now regularly reported to government AMR committees and submitted to WOAH. Bacteria resistant to commonly used antibiotics, and to clinically important drugs for humans such as Colistin, have frequently been detected within animals[17,18].

1.2 Methodology

This study employed mixed methods that combined a targeted literature review, analysis of Fleming Fund programme data, and field visits to Zambia and Nepal. The literature review focused on the advantages and limitations of animal disease surveillance methods, guiding key informant interviews and data analysis. The programme data included sample numbers, procurement records, and outputs from Fleming Fund regional grants that provided technical assistance for data and evidence use (TADE Africa[19] and TADEU Asia[20]). They completed costing studies in selected countries, but differences in methodologies made comparisons challenging. Field visits to Nepal and Zambia in early 2025 allowed the collection of qualitative insights through stakeholder engagement, site visits, observation of surveillance activities, and discussions on alternative strategies. Leveraging these case studies and consulting stakeholders enabled us to model the comparative cost-efficiency of different methodologies. Further details can be found in annex 1.1, in the separate appendices.

15. Acharya KP and Wilson RT (2019), ‘ **Antimicrobial Resistance in Nepal**’, *Frontier Medicine*, 6:105.
16. **Ministry of Fisheries and Livestock (2020) National Livestock Development Policy**.
17. Liu Y-Y, et al. (2016), ‘**Emergence of plasmid-mediated colistin resistance mechanism MCR-1 in animals and human beings in China: a microbiological and molecular biological study**’, *The Lancet Infectious Diseases*, 16(2):161–168.
18. Anyanwu M.U., et al (2021), ‘**Isolation and characterisation of colistin-resistant Enterobacterales from chickens in Southeast Nigeria**’, *Journal of Global Antimicrobial Resistance*’, 26, 93–100.
19. **African Society for Laboratory Science** (ASLM).
20. **International Vaccine Institute** (IVI).

1.2.1 Limitations

This study would have benefited from more case study examples from different regions, longer time periods for data collection, and pilot studies to test the hypotheses. However, the scope was limited because of time and resource constraints. Although the data and evidence use grants (TADE Africa[21] and TADEU Asia[22]) provided strong cost and output data, differences in methodology made comparable data analysis challenging. Finally, in Nepal, it would have been beneficial to observe sample collection outside the Kathmandu valley; however, this was not possible due to health and safety concerns.

2. Case Studies

2.1 Animal health surveillance in Zambia

At the start of Fleming Fund investment in 2018, Zambia, like other Fleming Fund countries, had an under-resourced animal health sector, minimal bacteriology expertise or equipment, and low levels of AMR awareness. It was within this context that the Fleming Fund provided the resources and technical support to implement farm-based active surveillance to build awareness, develop bacteriology capacity, and initiate the collection of high-quality data. Since then, there have been several notable achievements in Zambia, including the production of robust baseline AMR data, strengthened laboratory capacity, with a focus on bacteriology, and development of relevant animal surveillance protocols (Box 2). Zambia is an example of a country in which farm-based active surveillance has been consistently promoted throughout the Fleming Fund investment.

Box 2: Results in Zambia from Fleming Fund investments in animal health[23]

- Strengthened bacteriology capacity at five animal health laboratories through capital investment and training. Improvements were recorded against the Fleming Fund's animal health surveillance site roadmap, a standardised measure of surveillance site performance.
- Collection and testing of 4,758 samples (2021–2024) through the provision of consumables, equipment, training and AMR and AMU surveillance protocols for poultry, beef and dairy cattle. This has provided data for national action and facilitated the regular submission of data to WOAH.
- Development of an essential veterinary medicines list, standard treatment guidelines for beef and dairy cattle, and biosafety and biosecurity manuals.
- AMS was introduced into veterinary and para-veterinary university curricula.

2.1.1 Farm-based active surveillance

In Zambia, farm-based surveillance has been used throughout the Fleming Fund investment; these activities were an opportunity to train provincial staff in sample collection and processing methodologies and to collect valuable baseline data on the prevalence of AMR in the animal health sector. In February 2025, one of these activities was observed to understand the benefits and challenges of this strategy within the Zambian context.

One camp, five farms, five different experiences

Over two weeks, staff from the Central Veterinary Research Institute (CVRI) and the Department of Veterinary Services trained and supported provincial veterinarian staff in collecting and processing AMR and anti-microbial usage (AMU) samples according to protocol (Box 3). The observed activity occurred in Chipata, the capital of Eastern province, with sample collection in the first week, and sample processing, including culture, bacterial identification and AST, in the second. One morning's sample collection was observed, with five farms visited, each one delivering a very different experience. The team had to employ varying approaches depending on the equipment available, and some farms were close to a tarmac road while others were down earthen roads.

Box 3: Zambian cattle AMR sample collection protocol

Teams collect pooled faecal and milk samples according to protocol, with five individual samples per pool. The number of pooled samples depended on the size of the herd. Alongside these samples, an AMU survey was completed by a team member and the farmer.

Cattle to pooled samples

- 0 – 20 cattle = 1 pooled
- 21 – 50 cattle = 2 pooled
- 51 – 100 cattle = 4 pooled
- 100+ cattle = 6 pooled

21. African Society for Laboratory Science (ASLM).
22. International Vaccine Institute (IVI).
23. Country grantee in Zambia was The Centre for Infectious Disease Research in Zambia (CIDRZ).

Table 1: Details of experiences at each farm

Farm	Experience
Farm 1, – Beef – Faecal	Drove along a short dirt road to a village and waited an hour for the herd at the community crush. Loose poles allowed cows to escape, which delayed sampling and the AMU survey. The visit lasted 1 hour, 40 minutes for two pooled samples.
Farm 2 – Beef – Faecal	Drove down a long dirt road to a village without a crush; the farmers had to lasso and wrestle each animal to collect the faecal samples. This posed an injury risk to the farmers and the cattle. The visit lasted 1 hour, 30 minutes for two pooled samples.
Farm 3 – Beef – Faecal	Close to the main road, the farmers chased cows around a small pen to collect samples. It was challenging and risky for the farmers. The visit lasted 30 minutes for one pooled sample.
Farm 4 – Dairy – Milk	Drove along a well-maintained dirt road, the farm had an industrial metal crush with a head restraint. The dairy cattle were accustomed to being handled, which made sampling easier and safer. The visit lasted 30 minutes, with three pooled samples collected.
Farm 5 – Dairy – Milk	Drove along a well-maintained dirt road, the farm had a sturdy wooden crush, and the dairy cattle were accustomed to being handled. This made the sampling easier and safer. The visit lasted 30 mins for two pooled samples.

Figure 1: Photos of sample collection at five farms in Mwami camp

Clockwise from top left:

Farm 1 Beef: community crush with loose poles.
Farm 2 Beef: no crush, cows were lassoed.
Farm 3 Beef: small pen, cows were cornered.
Farm 4 Dairy: Industrial crush, easy sampling.
Farm 5 Dairy: sturdy wooden crush, easy sampling.

Source: Field visit in February 2025

2.1.2 Analysis of farm-based active surveillance in Zambia

Through discussions with stakeholders and observing farm-based active surveillance in Zambia, several advantages and disadvantages were noted and apply to comparable countries.

> The mentorship and training have been really impactful for maintaining my skills and technical capabilities."
>
> **Laboratory technician in Chipata**

Advantages

Developing a strong foundation of data

Unregulated use of antibiotics in Zambia's animal sector means that a lack of data and analysis is a significant gap in their AMR surveillance system. Farm-based active surveillance provides accurate, traceable AMR and AMU data that informs policy development, investment decisions, and progress monitoring.

Capacity development

At baseline, Zambia had very little bacteriology and AMR investigation capacity, especially in provincial areas. Farm-based active surveillance, as a dedicated AMR activity, provided focused time for training and mentorship in field and laboratory skills. It rapidly developed awareness, knowledge and skills.

Building awareness and trust

Distrust between government and farmers is common and often linked to concerns with tax, regulations, and expropriations. This dynamic can be a hindrance to animal health initiatives, especially for issues where awareness is low, such as AMR. Farm-based active surveillance provides a platform for engagement, showing that AMR and AMU surveillance is safe and beneficial. Farmers receive education and a livestock review without risk to market access, building awareness of AMR and trust between farmers and government.

Disadvantages

Resource-intensive

Dedicated AMR sampling in remote areas is extremely resource-intensive. In Zambia, collecting 36 pooled samples from 20 farms required two days of travel covering 220km and a week of planning and execution by eight laboratory staff, several of whom had travelled up to seven hours from the capital. Additionally, farmers invested significant effort to support sampling, which impacts other activities and could strain goodwill if regularly repeated. These high costs and effort mean that it's challenging to conduct at scale to achieve a representative data set. This work was achieved in Zambia with Fleming Fund support.

'Boom and bust' sample collection and processing

The resource intensity of dedicated farm-based sample collection limited the Fleming Fund-supported activities to once or twice a year per supported laboratory in Zambia. With minimal passive samples, this creates a 'boom-and-bust' cycle in AMR sampling and processing. This irregularity risks deskilling, frequent retraining, and expiry of consumables, which drives up costs. A steadier flow of samples would maintain skills better and optimise the use of supplies.

Sustainability and competing priorities

The resource demands of farm-based active surveillance make it unsustainable to undertake regularly without external financial support. In Zambia, AMR surveillance in the animal health sector is not a priority, with budgets focused on more immediate, economically important and notifiable diseases. In retrospect, this approach has created an AMR silo within the animal health sector that is misaligned with broader animal health priorities. As a result, AMR surveillance is viewed as an additional costly burden. In a sector that is already resource-constrained, farm-based active surveillance has not been cost-efficient enough to be included in governments' budgets.

2.1.3 Costs and outputs analysis in Zambia

The Fleming Fund regional grant, Technical Assistance for Data and Evidence in Africa (TADE Africa[24]) collected cost and output data across the five supported sites in Zambia. This study has leveraged data from animal laboratories in Chipata, Mongu, and CVRI, with the findings drawn from average costs across the three sites between 2021 and 2024. The sites in Choma and the University of Zambia (UNZA) were excluded because they were outliers; details can be found in annex 1.1.1, in the separate appendices. The costs were broken down into five components, and the costs required for set up vs ongoing (Box 4).

24. African Society for Laboratory Science (ASLM).

Box 4: TADE Africa AMR surveillance cost components

The TADE Africa grant collected the costs within five components.

Personnel: This incorporates staff salaries from the laboratory and veterinary staff that support the sentinel sites' bacteriology work. These are recurrent government costs.

Consumables: This includes the reagents and consumables that facilitate bacteriology and AST analysis, in addition to office supplies such as stationery and cleaning products.

Activities: All costs, including transport, training, meetings, sample collection and other costs related specifically to surveillance activities, including field and laboratory.

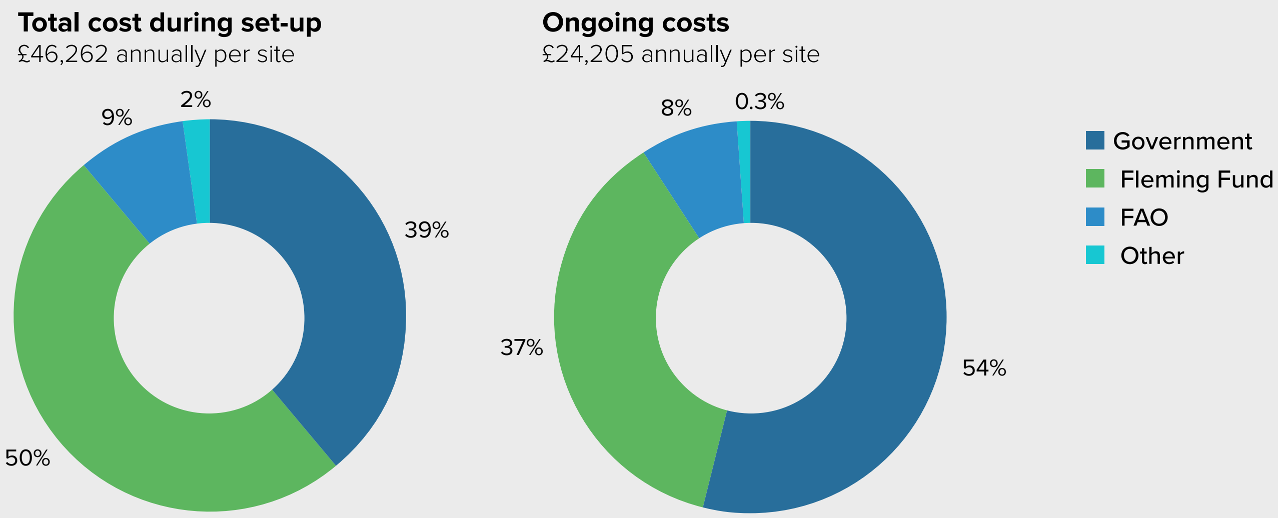
Equipment: Includes any equipment purchase and maintenance costs needed to run the bacteriology laboratory and office.

Infrastructure: Covering furniture, infrastructure investments, and maintenance costs to ensure the laboratories function effectively, with benefits extending beyond AMR surveillance.

Ongoing vs set-up: This data outlines the total cost to 'set up' a bacteriology laboratory, including equipment, refurbishment, and training. This provides a basis for estimating the ongoing costs of operation, assuming reduced training, equipment and infrastructure expenses. See annex 5.1.1 in separate appendices.

During 2021–2024, the Fleming Fund was a significant source of funding for the set-up of animal health surveillance laboratories, with the Government of Zambia providing most of the remaining resources (Figure 2). For the ongoing costs, although the Fleming Fund still accounts for 37% of the resources, the Government is the largest contributor. The 'other' source includes development partners such as GIZ, and resources provided via Zambia's National Public Health Institute (ZNPHI).

Figure 2: Source of funding for surveillance, 2021-2024, Zambia

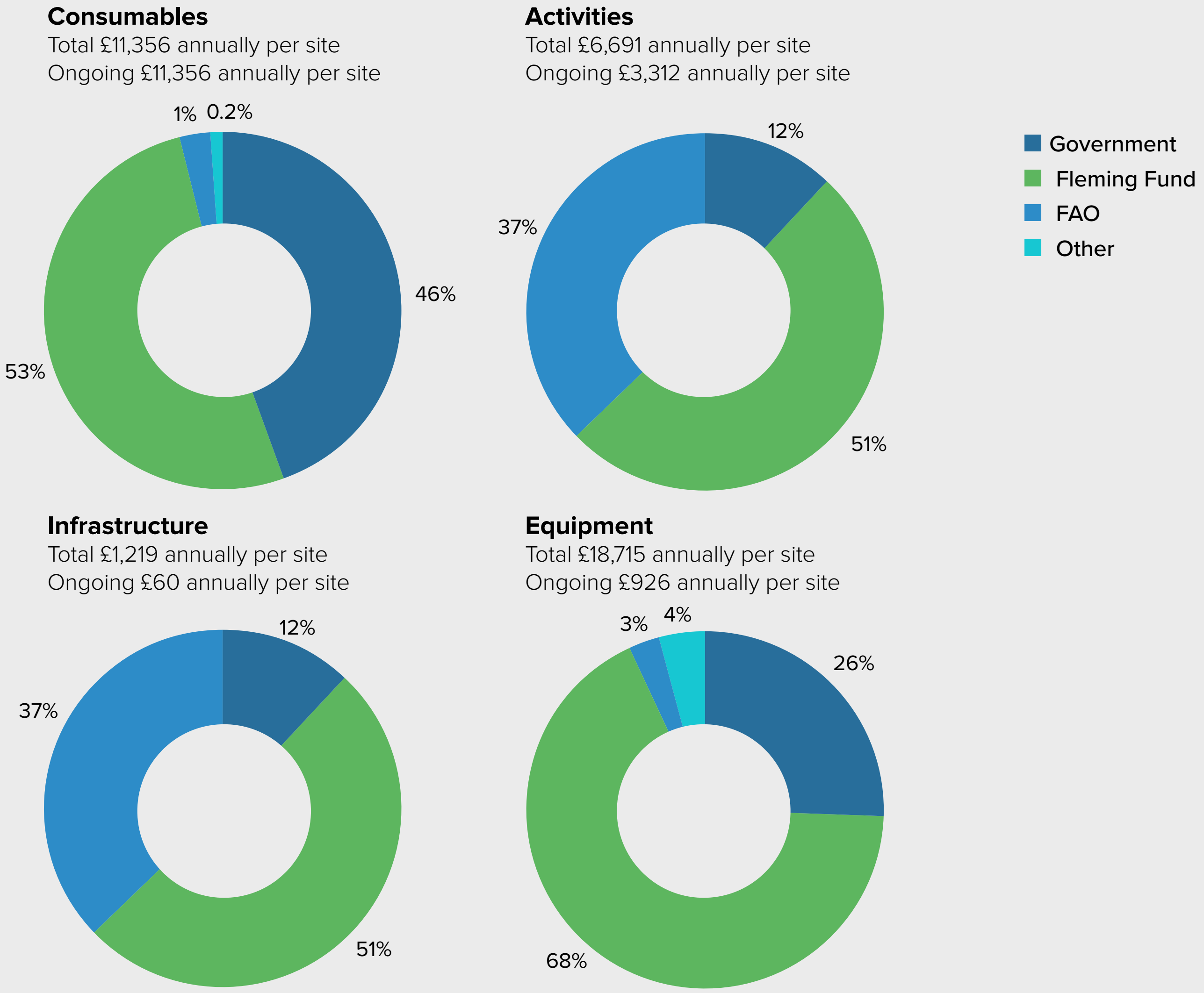


Source: TADE Africa Data

The Fleming Fund investment has been largely targeted at infrastructure[25], equipment and consumables, but has also supported surveillance-associated activities, e.g. transport and sample collection costs (Figure 3). All personnel costs were covered by the Government of Zambia but the distribution of funding sources by component highlights the lack of infrastructure and equipment at baseline for bacteriology in Zambia.

25. For the Fleming Fund, 'infrastructure' means support for internal fixtures and fittings (such as benchtops, sinks, etc), IT and electrics, and biosafety and security measures (e.g. installation of ducting). It did not involve major works such as the construction of new facilities.

Figure 3: Source of funding by component, 2021–2024, Zambia

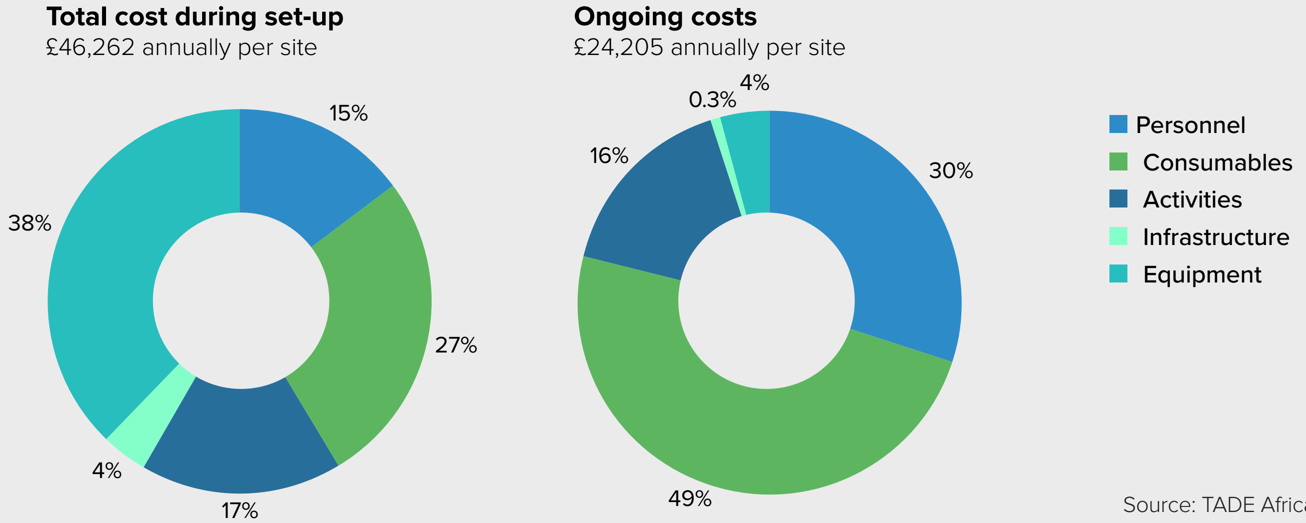


Source: TADE Africa Data

Across the selected sites, the overall spending between 2021 and 2024 shows that equipment is a dominant cost during set-up (Figure 4). However, once purchased, there is only a need to maintain it; this has been assumed as 5% of total equipment costs in the first five years of use, but typically this increases over time until the maintenance outstrips the cost of new equipment. The estimated lifecycle of equipment is ten years of use. Consumables are another significant component that proportionally increases when considering ongoing costs.

The Fleming Fund has provided instrumental investments in equipment, infrastructure and training during the establishment of bacteriology services. As laboratories move from set-up to ongoing operation, spending shifts significantly towards activities, consumables and personnel. Government becomes the main source of funding for these ongoing costs, and personnel will likely remain in post regardless, as AMR surveillance comprises a small part of their duties. Nonetheless, the Fleming Fund has provided 37% of these ongoing costs through its support for consumables and activities. This poses a major concern for long-term sustainability under the current cost basis.

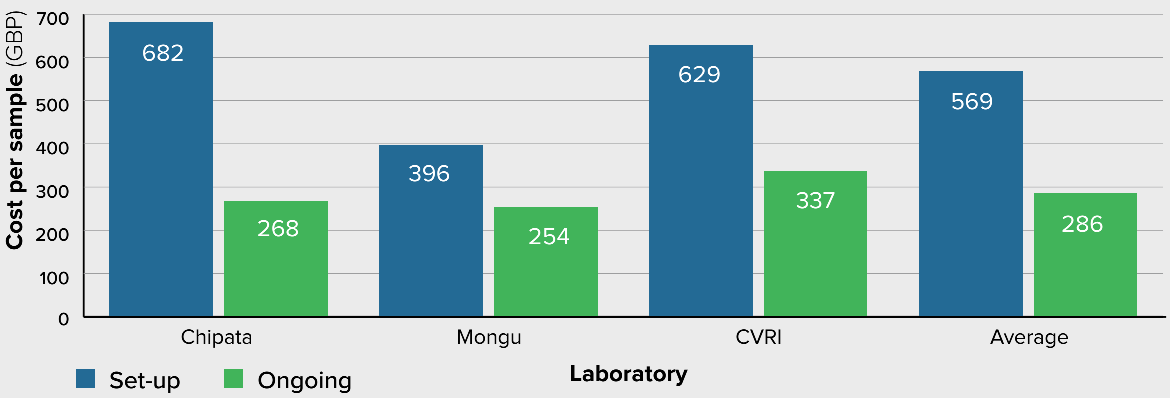
Figure 4: Cost components of spending, 2021–2024, Zambia



Source: TADE Africa Data

A total of 1,232 samples were collected and processed across the three selected sites over three years. The average cost per sample, including set-up costs, is £569, but when only factoring in ongoing costs, the figure reduces to £286 per sample. Nonetheless, this highlights the prohibitively high cost per sample of dedicated farm-based AMR surveillance, and the need to consider alternative methods of sample collection to improve the cost-efficiency and sustainability of activities. This also emphasises the difference between the cost per sample when considering the full investment required to establish bacteriology services, and those required to continue.

Figure 5: Cost per sample with Set-up vs Ongoing costs, 2021–2024, Zambia



Source: TADE Africa Data

2.2 Animal health surveillance in Nepal

Nepal was selected as a contrasting case study because of its progress in establishing animal surveillance for AMR within a One Health system. The result has been a high-quality baseline of data that has been used to shape policy and justify new government budget lines for surveillance (see Box 5).

Box 5: Results in Nepal from Fleming Fund investments in animal health[26]

- Strengthened bacteriology capacity at seven animal laboratories through capital investment and training, with improvements recorded against the Fleming Fund's animal health surveillance site roadmap, a standardised measure of surveillance site performance.
- Collection and testing of 22,504 samples across seven laboratories between 2018-2025 with consumables, equipment, training and developing surveillance protocols supported by the Fleming Fund.
- Data supported the development and implementation of policies, such as:
  - A ban on Colistin inclusion in animal feeds.
  - A government-endorsed essential veterinary medicine list.
  - An AMS action plan detailing a framework for veterinary hospitals, livestock farms, aquaculture production systems, animal-source fresh produce and the wildlife sector.
- Practitioner engagement programmes have been developed and delivered in collaboration with the Government. Selected farmers are being supported to improve AMU and farm management practices such as administration of vaccines, water hygiene, biosafety and biosecurity.

26. Country grantee in Nepal was **FHI 360**.

Box 6: The geography of Nepal in the context of animal health

Nepal is located along the Himalayan range, with 83% of the land classified as hilly or mountainous. Its rugged topography, scattered settlements, and underdeveloped road network make livestock management difficult. Limited access to veterinary services, markets, and farms – especially in remote districts – restricts vaccine delivery and timely disease response. These constraints may encourage farmers to purchase antibiotics inappropriately from rural agri-vet businesses, which contributes to AMR.

2.2.1 Slaughter sites and integrated surveillance

Nepal is an example of where the Fleming Fund supported a transition from farm-based sample collection to slaughter site[27] sampling to improve cost-efficiency and support integration within a One Health system (Box 7). While some farm-based surveillance continued, including for AMU surveys, it is conducted opportunistically alongside other animal health tasks, and the main source of AMR samples is slaughter sites. In June 2025, selected slaughter sites were visited to observe where and how samples were collected to understand how the strategy was implemented.

Box 7: Integrated AMR surveillance in Nepal

Nepal has advanced One Health surveillance through coordinated sampling by the Ministries for Health, Livestock and Environment[28]. The initiative follows the World Health Organization's integrated Tricycle protocol but is locally referred to as 'joint' surveillance to highlight the collaborative relationship between ministries. Supported by Fleming Fund Fellows and the Country Grant, the second round of integrated surveillance was completed between July and September 2025. Animal faecal samples were collected from slaughter sites, human samples from pregnant women and urinary tract infection (UTI) patients in local hospitals, and environmental samples from the slaughter site (Figure 6) and health facility effluent, as well as upstream and downstream river sites. The aim is to map resistance patterns and AMR transmission pathways across sectors.

Slaughter site sample collection sites

Three slaughter sites in the Kathmandu valley were observed, all in easily accessible urban settings (Figure 6). The sites were typical of those found across Nepal and are generally in population centres, although rural regions are still difficult to reach and have lower throughput. The sites varied in formality and scale, but all discharged blood and waste into the municipal sewers. Each site processed several hundred chickens daily from local farms, and all three could be visited within an hour, enabling efficient sample collection.

Figure 6: Nepalese slaughter sites in the Kathmandu valley

Clockwise from the top right:
Site 1: Small informal shop in Jagati Bhaktapur
Site 2: Mid-sized shop in Jagati Bhaktapur
Site 3: A larger facility connected to a shop in Sankhamul, Kathmandu. The three photos show the sewage drain, live chicken storage with deceased animals and the processing room.

Source: Field trip, June 2025

27. A 'slaughter site' refers to a space in which slaughtering, processing and retailing occur within the same premises. Broiler chickens were purchased from farmers, then slaughtered and processed to order for consumers. It is the equivalent of an abattoir.
28. Ministry of Health and Population, Ministry of Agriculture and Livestock Development, and Ministry of Forests and Environment.

2.2.2 Analysis of slaughter site sample collection in Nepal

Through discussions with stakeholders and observing the sample collection sites in Nepal, several advantages and disadvantages of slaughter site sample collection were noted.

Advantages

Reduced logistics and large animal catchment

Slaughter sites offer a centralised sampling point in population centres, reducing travel and logistical costs. It is also a point in the livestock value chain, in which many local animals pass through, therefore, samples provide data that is representative of the local farming economy while enabling the efficient collection of a large number of samples.

Building awareness and trust in the market

Slaughter site sampling creates an opportunity for regular interaction between government staff and site operators, fostering trust and collaboration. These engagements help raise awareness of AMR and AMS amongst processors and other market operators, demonstrating that surveillance is safe, non-disruptive, and beneficial for food safety and market reputation.

Public health relevance and opportunities for integrated surveillance

Samples collected from a slaughter site offer strong public health relevance, as samples come from animals entering the food chain. Therefore, data can be directly linked to consumer and worker safety and AMR risk. Additionally, because it is a point in which humans and animals interact, it offers opportunities for integrated surveillance sampling.

Disadvantages

Reduced traceability and representativeness

Although slaughter site samples provide a snapshot of local farms, they are not fully representative. There is a bias towards animals that are sent for slaughter while excluding those that are sick or not for slaughter, such as dairy cattle or egg-laying hens. Additionally, certain species (e.g. poultry) or larger farms may be overrepresented. Finally, the data cannot be easily traced to an individual farm or its production practices, therefore, limiting the ability to identify AMR drivers or target interventions.

AMU data and education

As there are no farmers present at a slaughter shop, it is not possible to collect AMU data or to engage with farmers to build awareness and deliver education on AMS, biosafety, or biosecurity.

Accuracy and sample integrity

Poor hygiene and biosecurity at slaughter sites can lead to cross-contamination, affecting bacteriology and AST results. Environmental contamination may obscure whether resistance originates from the animal or the site environment, complicating interpretation.

2.2.3 Drivers of change in Nepal

Several factors shaped Nepal's approach to AMR surveillance and its progress in building a One Health system. While some are unique to Nepal, they offer valuable lessons for other countries.

Logistical challenges and cost-effectiveness

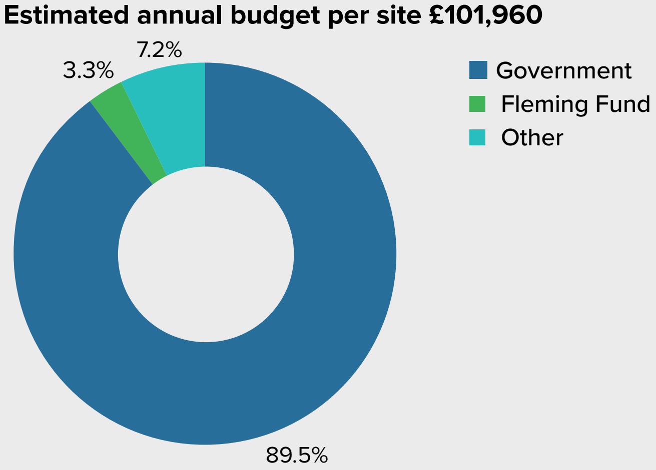
Cost-effectiveness has shaped Nepal's AMR surveillance approach, with the Director of the Central Veterinary Laboratory emphasising that it is at the core of all their activities. Severe logistical challenges due to rugged terrain and poor road networks have fostered an opportunistic culture during field visits (Box 6). Combining multiple objectives, such as stakeholder education, vaccinations, and sample collection for various diseases within one trip, is a core objective. For example, poultry slaughter sites are used to collect samples for Avian Influenza serology, Salmonella food safety testing, and AMR.

This strategy prioritises population centres and value chain points where animals are aggregated, which lowers sampling costs. Farm-based surveillance persists but is opportunistic, and collection frequency depends on reagent availability to minimise wastage. While this approach sacrifices farm-level traceability, it ensures affordability and sustainability within government budgets.

Previous zoonotic experience and One Health

Previous zoonotic disease outbreaks have heightened awareness of the need for animal health surveillance within a One Health system. A high prevalence of rabies and the continued threat of avian influenza increased government and public recognition of the importance of surveillance, and the fostering of inter-ministry collaboration. When the Fleming Fund promoted a One Health approach to AMR surveillance, Nepal was already aware of its significance and importance. Cross-sector relationships were further supported by Nepal's well-connected bureaucracy, where a small population and familial ties across sectors facilitated familiarity and cooperation among officials.

Figure 7: Sources of funding, Nepal, 2021-2023



Source: TADEU Asia data

Box 8: TADEU Asia AMR surveillance cost components

The TADEU Asia grant collected costs within four components[30]

Human Resources: This incorporates staff salaries from the laboratory and veterinary staff that support the sentinel sites bacteriology work. These are recurrent government costs.

Consumables: This includes the reagents and consumables for AMR surveillance that facilitate bacteriology analysis, in addition to office supplies such as cleaning products.

Allowances: Covering per diem or transportation costs related to travel and field duties.

Other costs and equipment: Encompassing equipment purchase, maintenance, and utility costs.

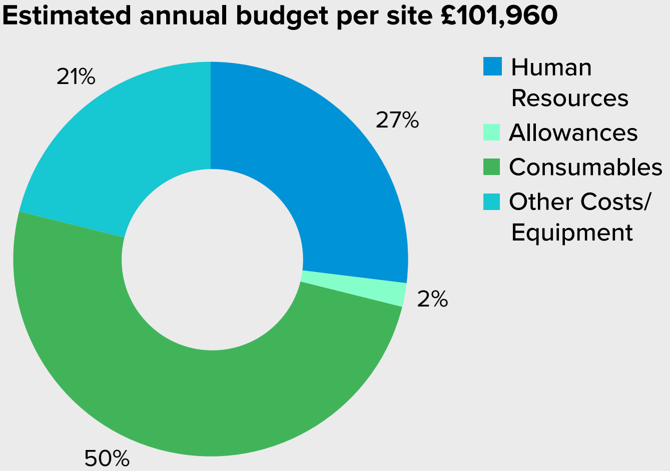
2.2.4 Costs and outputs of AMR surveillance in Nepal

The Fleming Fund regional grant Technical Assistance for Data and Evidence Use in Asia (TADEU Asia[29]) collected cost and output data in Nepal. The grant collected data from Pokhara veterinary laboratory and the National Avian Disease Investigation Laboratory (NADIL) in Chitwan. The findings of this study were drawn from average costs across the two sites selected by the Government of Nepal between 2021–2023. The data collected by TADEU Asia was combined with further programmatic data, but it did not include equipment purchased before 2021 and is thus a reflection of the 'ongoing' cost of AMR surveillance, rather than the total cost of setting up the bacteriology laboratory.

At the two sites during 2021–2023, the government provided almost all the funding. This indicates that the government is committed to animal health AMR surveillance and a positive sign for sustainability. The 'other' source of funding included unnamed development partners.

TADEU Asia placed costs into four components as described in Box 8, above. Consumables are the largest cost component for the surveillance sites (Figure 8). Human resources and other costs, including equipment, are similar in proportion, but the allowances component, which includes sample collection and transportation, is a fraction of the total budget. This could reflect the cost-efficient sample collection strategies that have been implemented in Nepal. These efficient strategies could also be observed in the £126 per sample cost found at the selected sites, which is significantly lower than those found in Zambia[31]. TADEU Asia's analysis identified that sample throughput was another important factor that shaped efficiency. As discussed in Box 5, the Fleming Fund supported the collection of 22,504 samples across seven sites in Nepal. This is considerably more than Zambia and would have contributed to the differences in the cost per sample.

Figure 8: Cost components of spending, Nepal, 2021-2023



Source: TADEU Asia data

29. **International Vaccine Institute** (IVI).
30. The costs collected by TADEU Asia did not include costs from the wider surveillance system, such as centralised data management, policy development, and coordination.
31. Differences in exchange rates, purchasing power, local market conditions, and reporting methodologies add complexity when making direct comparisons between cost per sample in Nepal and Zambia.

3. Analysis of different strategies

3.1 Strengthening surveillance systems

Six key themes for strengthening surveillance systems emerge in the literature: data infrastructure, capacity, representativeness of data, policy landscape, stakeholder engagement, and sustainability factors. Effective systems require accurate, traceable, representative, timely and standardised data to inform policy and investment decisions. These depend on proper sample collection and processing, supported by skilled field and laboratory staff, adequate equipment, good infrastructure, sufficient budget, and enabling policies. Successful implementation relies on good communication and engagement between laboratory staff, field veterinarians, farmers, and relevant ministries including agriculture, health and finance. Sustainability demands practical and cost-effective methodologies. As systems mature, approaches must be refined to maintain data quality, meet objectives, and ensure long term viability[32].

The Fleming Fund has advanced these priorities by strengthening skills and laboratory capacity, establishing data infrastructure, promoting representative and traceable sampling, engaging stakeholders, and advancing policies and standards.

In Nepal and Zambia, the Fleming Fund investment has delivered impact with the establishment of baseline data, rising awareness of AMR, trust built with farmers, and strengthened standards and technical capacity. Comparing these case studies reveals contrasting approaches and prospects for sustainability beyond development partner investment. Both countries began with farm-based surveillance, but with support from the Fleming Fund, Nepal adapted its sampling methodology due to the costly nature of implementing farm-based surveillance in challenging terrain. Nepal also successfully integrated animal health into a One Health system, leveraged data to inform policy, and secured budget lines for limited surveillance going forward. While Nepal's prior One Health experience and awareness gave it an advantage over Zambia's underfunded sector and low baseline, Zambia has not yet refined its strategy as its system matured, which has reduced the likelihood of sustainability. Comparing these strategies highlights trade-offs in design, effectiveness, and cost efficiency, but also the need to adapt a strategy for long term sustainability.

Strategies to be compared

As demonstrated in Nepal and Zambia, there are several different methodologies that can be employed for animal health AMR surveillance. Zambia is an example of dedicated farm-based sampling, while Nepal demonstrates slaughter site and wastewater sampling within an integrated One Health approach. Other options include opportunistic sampling during routine activities, such as vaccination campaigns, disease surveillance, movement control, or export certification, which leverage existing logistics and touchpoints. These strategies could offer more cost-efficient alternatives to farm-based sampling, though each carries distinct advantages and limitations.

Key comparators within a Value for Money approach

This evaluation has focused on cost efficiency as a key comparator, assessing inputs (e.g. sample collection, staff, transport, analysis) and outputs (quality and quantity). While economy and effectiveness have emerged in discussions of training potential and One Health promotion, they have not been explored in the same depth.

3.2 Costing different approaches

Each potential surveillance strategy requires different logistics and time commitments that result in variations in cost. The cost-efficiency of alternative AMR sampling methodologies were modelled using TADE Africa's comprehensive data from Zambia.

Modelling details

The modelling of alternative sampling strategies was based on Chipata's veterinary laboratory cost and output data in 2023-2024. This site was selected because its costs aligned with the national average and the laboratory was observed during field visits, confirming that only farm-based surveillance was completed. The ongoing costs at this site represented the baseline of farm-based surveillance[33]. Stakeholder discussions and field observations in Nepal and Zambia allowed a set of assumptions to be made and were used to estimate the differences in cost components for each strategy. These assumptions included reductions in personnel and activities cost components, though these assumptions have been made conservatively and further efficiencies could be found.

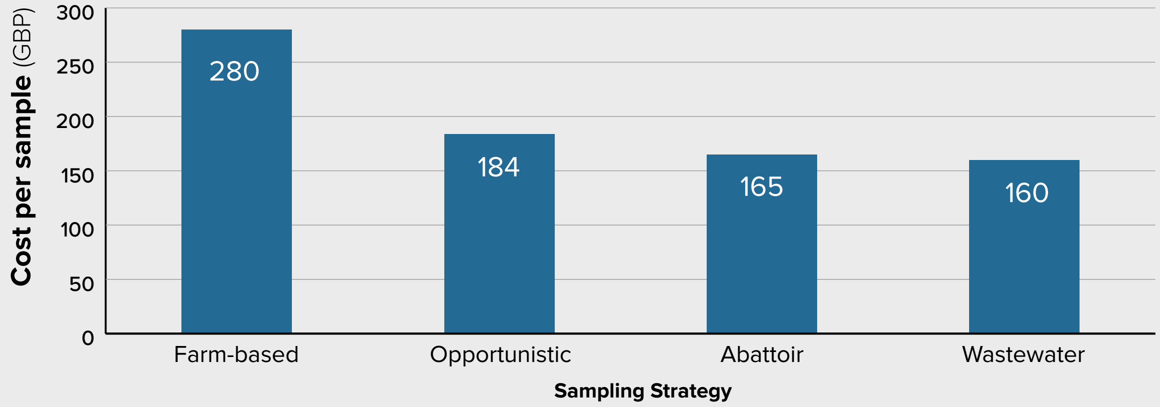
32. Do, P.C., et al. (2023) '**Strengthening antimicrobial resistance surveillance systems: a scoping review**', *BMC Infectious Diseases,* 23, 593.

This study's modelling aligned with TADEU Asia's finding that increased sample throughput had a positive effect on the cost per sample. However, given that the Fleming Fund had supported a significant proportion of the ongoing costs of AMR surveillance in Zambia, it is likely that the budget will contract going forward. Therefore, this study has focused on a scenario in which the number of samples collected in 2023-2024 would continue (56.5 annual average). This facilitated the identification of how the sample throughput could be maintained, but with alternative strategies requiring lower budgets. The cost per sample was used to reflect the cost-efficiency of each strategy. Further details can be found in annex 1.1.1, in the separate appendices.

Cost-efficiency of alternate strategies

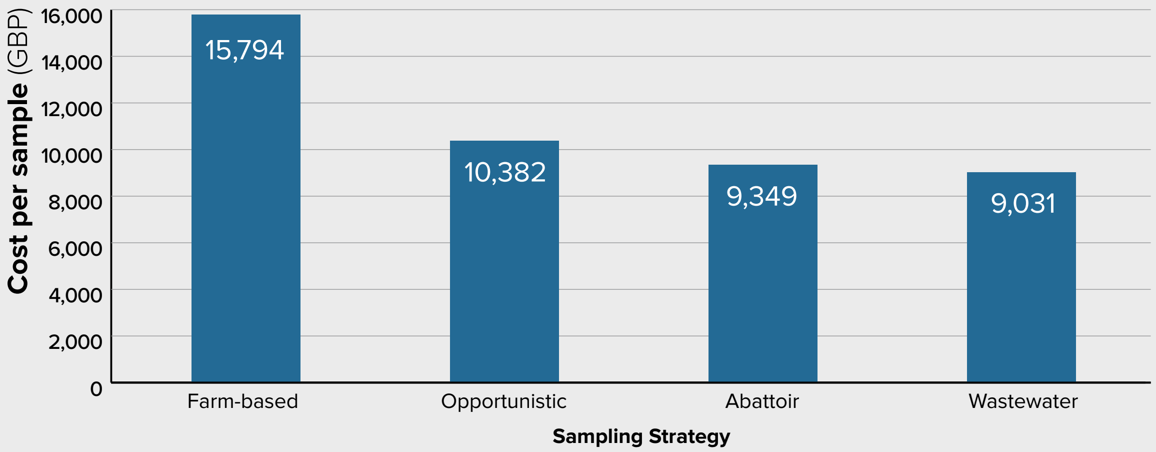
The cost per samples and annual budgets seen in Figure 9 and Figure 10 show that the alternative methodologies are likely to be more cost-efficient.

Figure 9: Cost per sample using alternative strategies, Chipata, Zambia



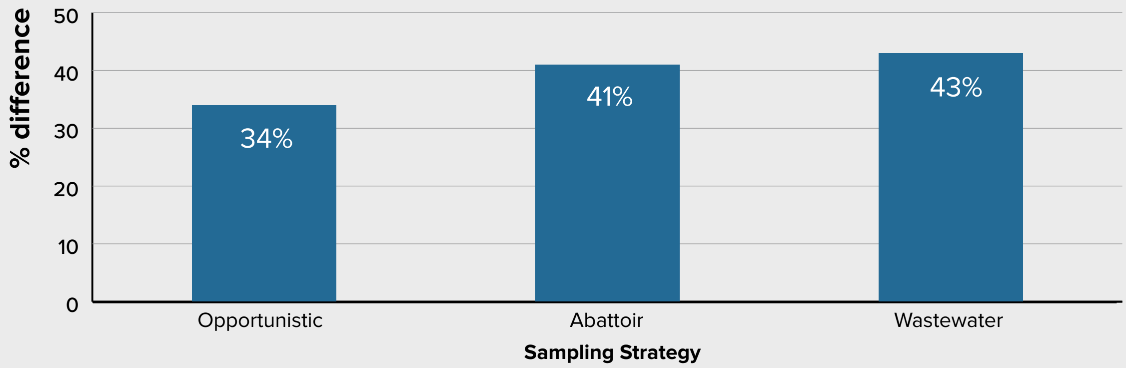
Source: TADE Africa data modelled by the Fleming Fund Management Agent

Figure 10: Annual budget using alternative strategies, Chipata, Zambia



Source: TADE Africa data modelled by the Fleming Fund Management Agent

Figure 11: Percentage cost saved from baseline farm-based surveillance, Chipata, Zambia



Source: TADE Africa data modelled by the Fleming Fund Management Agent

33. As discussed in Box 4, costs were separated into the total costs including 'set up' and an estimate of the 'ongoing' surveillance costs, assuming reduced training, equipment and infrastructure expenses.

It is also important to note that the Fleming Fund has accounted for 37% of the estimated ongoing cost of animal AMR surveillance in Zambia (Figure 2). Given the closure of the Fleming Fund, and that government officials have indicated that farm-based sample collection is too costly to continue, these alternate strategies could enable continued sample throughput at a reduced cost that aligns with current government budgets[34]. Though increased sample throughput is associated with reduced cost per sample, this presents an opportunity for other funders to efficiently expand surveillance in the animal health sector.

3.3 Surveillance strategy effectiveness

The differences in approach to surveillance also result in variations in the quality of the output data. One is a resource-heavy approach which provides robust baseline estimates; the other is more efficient, but less representative and robust. This section will discuss these factors in relation to Zambia and Nepal, to consider the different qualities of each strategy and how they affect effectiveness.

3.3.1 Comparing different strategies for animal health surveillance

Key comparators for animal health surveillance

To assess the benefits and limitations of different surveillance strategies, a set of comparators were developed through key informant interviews, stakeholder discussions, field observations, and a targeted literature review (Table 2). These comparators have been used to evaluate the effectiveness of alternative methodologies for AMR surveillance in animal health, with Nepal and Zambia as examples of how each method could be applied.

Table 2: Key comparators for animal AMR surveillance methodologies

Factor	Reasoning
Data traceability and bias	Accurate, traceable data supports targeted surveillance and interventions, but biases may skew interpretation.
Frequency	A steady flow of samples maintains staff skills, ensures continuity, and reduces resource wastage.
Training potential	Methods that provide opportunities to train staff and educate stakeholders, such as farmers, build awareness and local capacity.
Sampling feasibility	Considering logistical challenges, infrastructure, equipment, and stakeholder engagement requirements.
Policies and regulation	Activities supported by law or regulation offer strategic advantages for opportunistic AMR sampling.
One Health promotion	AMR is a cross-sectoral challenge; methods that encourage One Health collaboration strengthen integrated surveillance systems.
Cost-efficiency	Sustainability depends on practical and efficient solutions that can be incorporated within limited budgets.

Farm-based active surveillance

As discussed in Section 2.1.2, dedicated farm-based AMR surveillance offers clear benefits but major sustainability challenges. It generates traceable data, strengthens laboratory capacity, and fosters farmer trust and AMR awareness. However, it is highly resource-intensive and creates irregular sampling cycles that erode skills and increase consumable waste. It is difficult to sustain without donor support, especially when misaligned with broader animal health priorities. It may be more cost-effective to leverage this strategy as a targeted investigative tool (such as to establish a baseline or respond to an outbreak).

Opportunistic surveillance sampling

The animal health sector holds different incentives for human AMR surveillance. In contrast to human health, where AMR data is a byproduct of essential diagnostics, the bacteria being monitored in animals rarely affect the animals' health. This reduces the motivation for costly standalone AMR activities. Aligning surveillance with existing animal health activities could make participation more attractive by sharing resources and reducing costs. As demonstrated in Nepal, opportunistic sampling during these routine activities can offer a practical and sustainable alternative to standalone sampling. Several activities offer such an opportunity.

34. This does not consider the impact of broader donor budget cuts and how that will affect government spending capacity.

Other disease surveillance

Several notifiable diseases, such as Foot and Mouth Disease, African Swine Fever, Bovine Tuberculosis, Brucellosis, Lumpy Skin Disease, Newcastle Disease, Anthrax, and Avian Influenza, affect livestock productivity and drive government priorities. Most countries allocate budgets for *ad hoc* investigations and regular surveillance to protect productivity and export markets. In Zambia, the animal health budget is almost entirely focused on the management of these diseases and supporting related vaccination or disease investigation campaigns. This presents an opportunity to share logistics with other disease surveillance activities and collect farm-specific AMR samples and AMU data.

Vaccination campaigns

Most countries, including LMICs, have comprehensive vaccination initiatives. In Zambia, the government funds campaigns in each province every month, following a set and predictable schedule that covers poultry, goats, beef and dairy cattle. Generally, for cattle and goats, provincial and central staff set up camps for 7-10 days, with farmers bringing their herds for vaccination. Herd ownership during vaccination events is often unclear, which limits the traceability of AMR data, but AMU surveys could be completed with individual farmers. Poultry and pig vaccinations occur at farms, offering the chance to collect traceable samples for these species. These campaigns present an opportunity to share logistics and collect samples at regular intervals throughout the year. Nonetheless, although this strategy would enable the collection of data that is representative of a whole province, it would be biased towards animals presented for vaccination and may not represent the whole population.

Movement control and export certification

To limit the spread of infectious diseases, Zambian law requires animals to have disease screening before moving provinces, and international animal health regulations require that farmers attain certification for export of animal products. These measures prevent disease spread and ensure product quality for foreign markets. As veterinarians are already conducting tests, these touch points offer an opportunity for AMR and AMU sample collection. There would be minimal additional logistics and farmers are compelled by law or economic reasons to participate. Nonetheless, this methodology would not offer fully representative data, since only certain provinces permit animal movement and very few have export markets.

One notable example from Zambia is Salmonella certification for day-old chick exports. Farms must conduct extensive sampling every 3-6 months, including from animals and the farm environment. This represents a promising source of samples from participating poultry farms, although it is obviously not representative of the whole industry. Nonetheless, associating AMR with broader proof of disease absence offers incentives for farms to improve their AMS and product marketability.

Abattoirs and slaughter sites

Veterinarians commonly collect samples at abattoirs due to their role in meat inspection. In Zambia, the government mandates veterinarians and para-veterinarians[35] to complete inspections of small, informal slaughter sites, while industrial abattoirs employ private veterinarians for inspections and statutory sampling. As these sites provide meat for consumption, the products an insight into the resistant bacteria potentially transmitting from animals to humans. The point of slaughter offers a cost-efficient opportunity to sample many animals from a local region without farm visits. Disadvantages are the possible need to train inspectors, some slaughter sites are low volume, and farm-specific data would be limited. Yet, as seen in Nepal, slaughter sites offer a community-level view of AMR that can direct further investigation at a reduced cost.

Wastewater surveillance

Wastewater surveillance for AMR involves testing effluent from farms, abattoirs, hospitals, and household sewers to detect resistant bacteria[36]. In Zambia, the Environment Agency (ZEMA) is very keen to tackle AMR by supporting wastewater testing. The Churches Health Association of Zambia (CHAZ) and ZNPHI have conducted several pilot studies for disease surveillance using 'Moore swabs' and have concluded that it could be a cost-effective and useful methodology[37,38].

35. A community-based animal health worker with limited formal veterinary training who provides basic livestock care and disease prevention services, often bridging gaps in access to qualified veterinarians.
36. This e*fflue*nt may flow directly or indirectly into rivers.
37. Shempela, D.M. et al. (2024), '**Wastewater Surveillance of SARS-CoV-2 in Zambia: An Early Warning Tool**', *International Journal of Molecular Sciences*, 25, 8839.
38. Saasa, N. et al. (2024), '**Detection of Human Adenovirus and Rotavirus in Wastewater in Lusaka, Zambia: Demonstrating the Utility of Environmental Surveillance for the Community**', *Pathogens*, 13, 486.

As seen in Nepal, this approach provides a cost-efficient, non-invasive method to monitor AMR trends across sectors, and offers a community-level snapshot that supports One Health integration. It can also act as an early warning system, as demonstrated during COVID-19, and is easy to implement at chosen locations periodically. However, coverage is limited in rural areas due to an absence of sewerage systems, reducing representativeness. Mixed sources make it difficult to identify the origin of resistant bacteria, and resistance may evolve in wastewater environments, potentially leading to an overestimation of upstream prevalence. Despite these limitations, wastewater sampling offers a scalable, flexible and cost-efficient strategy that can act as an alert system that complements and directs further investigation.

Integrated One Health surveillance

Integrated surveillance combines sampling from animals, humans, and the environment to assess AMR transmission routes and public health risks across a One Health framework. However, it is complex, requiring strong intersectoral collaboration and coordination of sampling across time and locations. Robust analysis depends on Whole Genome Sequencing (WGS) to compare isolates from different sources. This level of collaboration can be politically challenging, and most countries lack national WGS capacity[39]. As seen in Nepal, slaughter sites can serve as practical hubs for joint animal and environmental sampling, which can then be combined with data from local health facilities to achieve broader multisectoral coverage. While modelling the costs for integrated surveillance has not been completed due to its complexity, it remains a benchmark for comparison.

Table 3: A comparison of alternative methodologies[40]

Factor	Farm-based	Opportunistic sampling			Slaughter sites/ abattoirs	Wastewater
		Vaccination	Movement control	Other disease surveillance		
Data traceability and biases	Farm-specific AMR and AMU data. Large scale is costly	Regional AMR and farm AMU. Vaccinated animals only	Farm-specific AMR and AMU. Not nationally representative	Farm-specific AMR and AMU.	Regional AMR data. Only animals for slaughter	Area-specific AMR data. Not animal-specific
Potential Frequency	Ad-hoc	Periodically and ad-hoc	Ad-hoc	Periodically and ad-hoc	Periodically and ad-hoc	Periodically and ad-hoc
Training potential	Stakeholders and staff	Stakeholders and staff	Stakeholders and staff	Stakeholders and staff	Stakeholders and staff	Staff
Sampling feasibility	Challenging and costly	Simple shared logistics	Simple shared logistics	Simple shared logistics	Simple, market engagement required	Simple and low cost
Policy & regulatory support	Voluntary	Policy support	Mandated by law	Policy support	Policy support	Voluntary
One Health promotion	Animal health only	Animal health only	Animal and food safety	Animal and food safety	Animal, environment and food safety	Animal, human, and environment
Cost per sample	£280	£184	£184	£184	£165	£160

4. Cost-efficient and practical AMR surveillance

Farm-based surveillance offers clear benefits, especially when initially strengthening surveillance systems. Yet its resource intensity is a challenge for the sustainability of activities. As seen in Nepal, a shift towards a more cost-efficient strategy that aligns with other animal health activities supports budget allocation towards AMR surveillance.

Unlike human AMR surveillance, where data is a byproduct of essential diagnostics, the same bacteria being monitored in animals for public health reasons rarely affect the animal's health or productivity. Therefore, surveillance in the animal health sector does not require the same level of individual animal traceability, but rather a species, farm, district or regional view of AMR. What is required is a realistic, affordable approach that leverages existing animal health activities and targets points in the livestock value chain where animals are congregated, such as abattoirs, vaccination campaigns, and export certification. These can be complemented by environmental strategies like wastewater sampling to provide a broad picture of AMR trends within a community. These alternative methodologies produce less traceable data but can identify emerging resistance trends and trigger targeted farm-based sampling as

39. There are regional WGS hubs, such as those supported by the regional grant SEQAfrica, that can provide capacity to countries. The Danish Technical University (DTU) was the lead grantee for SEQAfrica.
40. See annex 5.1, in separate appendices, for details and assumptions made in modelling the costs.

an investigative tool. While no single strategy can deliver a comprehensive national picture, a combination of the strategies could improve coverage, sustainability and cost-effectiveness.

4.1 Recommendations

Avoid silos

Dedicated farm-based sampling for AMR, while valuable for strengthening capacity, building trust, and generating traceable data, is less cost-efficient than other methods and comes with significant risks to sustainability in LMICs. Focusing on dedicated farm-based AMR sampling creates a silo that promotes a perception of AMR surveillance as an additional cost rather than an essential component of animal health management. This disconnect reduces stakeholder buy-in and undermines sustainability. Embedding AMR surveillance within existing programmes, such as vaccination campaigns, disease control, and food safety, demonstrates that AMR monitoring can fit alongside broader animal health objectives within limited budgets and a One Health system.

Scan and target surveillance strategies

Animal health AMR surveillance must be practical and affordable. It does not always require the same level of traceability as surveillance in the human health sector. Alternative strategies could be used in combination to provide a steady flow of samples, keeping laboratories occupied and improving cost efficiency. While each method carries some biases, together they offer broadly representative coverage. These approaches could be used to scan and detect emerging resistance trends, triggering targeted farm-based sampling and AMS interventions when needed. This could switch farm-based sampling into a potentially cost-effective investigative tool.

Piloting a scan and target strategy

This study has identified that alternative AMR surveillance strategies could be more cost-efficient and effective, especially when used in combination. Further research is needed to understand the advantages, disadvantages and costs of a 'scan and target' methodology; alternative strategies are used to 'scan' and detect emerging resistance trends that trigger more specific farm-based sampling and AMS interventions. A pilot study would provide more comprehensive evidence to support policymakers in making budget and investment decisions.

Continue to adapt and refine strategies

The case studies described show that different starting points, previous One Health experience, and geography influenced the choices made by governments and grantees during the Fleming Fund. Both Nepal and Zambia established a baseline of data for future comparison, strengthened bacteriology capacity, and raised awareness of AMR as a challenge that requires resources. However, Nepal refined its approach over time, adopting more sustainable solutions that secured government budget lines. In contrast, Zambia persisted with dedicated farm-based AMR surveillance, and officials stated that it would not continue without external funding support. While farm-based AMR surveillance was critical for building capacity and awareness from a low baseline, maintaining and improving a system through reassessment and refinement is essential to maintain data quality, meet objectives, and ensure long-term viability[41].

Leveraging the opportunities left by the Fleming Fund

With the planned closure of the Fleming Fund in 2026, it is crucial to ensure that a One Health approach to AMR surveillance, which includes animals and the environment, continues to receive support. Across all the countries where the Fleming Fund has operated, there has been significant progress with raising awareness, a robust baseline of data, strengthened laboratory systems, and skilled human resources capable of implementing future AMR surveillance.

This presents an opportunity for continued investment to develop and refine animal health AMR surveillance systems. By aligning with government priorities and budgets, sample collection for AMR surveillance in animals can be maintained or expanded in a cost-efficient way that integrates with a One Health system and can provide data for policy and investment decisions.

41. Do, P.C., et al. (2023), '**Strengthening antimicrobial resistance surveillance systems: a scoping review**', *BMC Infectious Diseases*, 23, 593.

The Fleming Fund

UK International Development

Partnership | Progress | Prosperity

MOTT MACDONALD

@FlemingFund fleminggfund.org