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Strengthening Veterinary Epidemiology and One Health Capacity for Sustainable Livestock-Based Socio-Ecological Systems in the Indo-Pacific: A Multi-Level Capacity Development Model

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Abstract

Livestock systems underpin food security, livelihoods and socio-ecological resilience across the Indo-Pacific. However, endemic and emerging animal diseases, increasing human-animal-environment interactions, and limited epidemiological capacity continue to constrain livestock productivity and community wellbeing. The Asia Pacific Consortium of Veterinary Epidemiology (APCOVE) Phase II is a regional capacity-development initiative that aims to strengthen veterinary epidemiology and One Health capability across eight Indo-Pacific countries through four integrated activities: frontline field epidemiology training, intermediate epidemiology training, applied One Health training and faculty development. Supported by cross-cutting Monitoring, Evaluation and Learning (MEL) and Gender Equality, Disability and Social Inclusion (GEDSI) frameworks, APCOVE II adopts a systems-based approach to strengthening animal health systems. This paper argues that investments in human, institutional and network capacity represent a critical pathway towards resilient livestock-based socio-ecological systems. By combining participatory approaches, flexible learning models, institutional strengthening and regional collaboration, APCOVE II aims to enhance the ability of animal health systems to anticipate, detect and respond to complex disease challenges while promoting more sustainable and inclusive livestock development.

Keywords: veterinary epidemiology; One Health; capacity development; sustainable livestock systems; socio-ecological resilience

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Introduction

Livestock contributes substantially to food security, nutrition, income generation and livelihood resilience throughout the Indo-Pacific region. Yet livestock systems are increasingly challenged by endemic and emerging infectious diseases, climate variability, environmental degradation, land-use change and increasing interactions among people, animals and wildlife. These interconnected pressures disproportionately affect low- and middle-income countries, where limitations in veterinary services and epidemiological expertise constrain effective disease prevention and response.

Responses to animal health threats have traditionally focused on technical interventions such as diagnostics, vaccines and surveillance infrastructure. While these investments remain essential, their effectiveness ultimately depends on the capacity of individuals and institutions to generate, interpret and apply evidence. Human and institutional capability therefore constitute critical determinants of livestock-system resilience but often receive less attention than technological solutions. Capacity development should therefore be viewed as a core intervention within sustainable livestock development rather than a supporting activity.

The Asia Pacific Consortium of Veterinary Epidemiology (APCOVE) provides a regional model for addressing these challenges through participatory education, professional networking and institutional strengthening. Funded by the Australian Department of Foreign Affairs and Trade, APCOVE II brings together animal health professionals from Australia, New Zealand and eight Indo-Pacific partner countries (Cambodia, Indonesia, Laos, Malaysia, Papua New Guinea, the Philippines, Timor-Leste and Vietnam) to strengthen the prevention, detection and response to animal health threats affecting livestock productivity, wildlife conservation, public health and rural livelihoods[1]. To date, APCOVE has developed 36 open-access training modules in six languages and supported more than 200 trainees through field investigations, workplace-based projects and professional development activities[2].

Rather than viewing capacity development as the transfer of technical knowledge from high-income to low-income settings, APCOVE II adopts a collaborative model in which training programmes, field investigations and educational resources are co-developed with country partners and adapted to local socio-economic, ecological and institutional contexts[3]. This paper examines APCOVE II as a multi-level capacity-development model and explores its contribution to resilient livestock-based socio-ecological systems.

Conclusions and Outlook

APCOVE II addresses veterinary epidemiology and One Health capacity constraints through four complementary interventions operating at different levels of the animal health system: (1) frontline field epidemiology training centred on participatory outbreak investigations and surveillance in livestock systems; (2) intermediate epidemiology training combining multilingual open-access eLearning with mentored field projects addressing locally defined priorities; (3) applied One Health training focused on systems thinking, intersectoral collaboration, community engagement and leadership; and (4) faculty development for epidemiology educators to strengthen long-term regional teaching capacity[4]. These activities are underpinned by programme-wide MEL and GEDSI frameworks designed to support adaptive management, equitable participation and continuous improvement.

The frontline field epidemiology programme, delivered in Cambodia, Laos, Papua New Guinea and Timor-Leste, develops practical competencies among government veterinarians, animal health officers and other professionals responsible for disease detection and response. Through participatory outbreak investigations, surveillance activities and simulation exercises, participants strengthen skills in epidemiological analysis, disease investigation and risk assessment under real-world conditions. The intermediate epidemiology programme, delivered in Indonesia, Malaysia, the Philippines and Vietnam, combines multilingual eLearning resources with mentored field projects addressing nationally relevant disease priorities. This approach bridges

the gap between theory and practice by enabling participants to apply epidemiological approaches directly within their workplaces while generating locally relevant evidence. The open-access and multilingual nature of the programme further broadens access to specialised training and supports more equitable workforce development. The One Health component, delivered across all eight partner countries, responds to the reality that many contemporary livestock-health challenges arise from interactions among people, animals and ecosystems. Consequently, the programme emphasises systems thinking, leadership, stakeholder engagement and interdisciplinary collaboration. Participants are encouraged to analyse disease emergence as the outcome of broader socio-ecological processes including environmental change, wildlife interactions, agricultural intensification and land-use change. GEDSI principles further encourage reflection on how disease risks, resource access and participation in decision-making vary among social groups. Faculty development represents the most institutionally focused component of APCOVE II. Through curriculum development, teaching innovation and educational leadership activities, the programme aims to strengthen the capacity of universities and training institutions to develop future epidemiologists and One Health practitioners. A regional community of practice in collaboration with FAO further connects epidemiology educators across partner countries for sharing teaching resources, peer learning and mentorship beyond formal training activities. By embedding expertise within local institutions, APCOVE seeks to create lasting educational capability that extends beyond project lifecycles.

Capacity Development as a Socio-Ecological Intervention

The APCOVE II experience suggests that capacity development should be viewed not simply as knowledge transfer but as an intervention in livestock socio-ecological systems. Disease risks emerge from interactions among biological, environmental, social and economic processes, requiring professionals who can generate evidence, adapt to change and coordinate responses across sectors. Investment in human, institutional and social capital is therefore central to system resilience.

Frontline and intermediate epidemiology training strengthen surveillance, disease investigation and evidence-based decision-making, enabling earlier detection and more targeted responses. Participatory and GEDSI-informed approaches further strengthen relationships between veterinary services and livestock-owning communities, improving both data quality and the acceptability of disease-control measures. The One Health component recognises that livestock-health challenges are shaped by drivers beyond the veterinary sector, including environmental change, biodiversity loss and human behaviour. Effective disease management therefore depends on systems-thinking competencies and the ability to work across disciplinary and institutional boundaries. Faculty development and MEL activities strengthen the educational systems responsible for generating future expertise, promoting continuous learning and institutional adaptation. Together, these elements position capacity development as a mechanism for long-term transformation rather than short-term training delivery.

However, important challenges remain. Common evaluation metrics, such as participant numbers and satisfaction, provide limited evidence of impacts on disease control, livestock productivity, livelihoods or ecosystem health. Demonstrating these outcomes requires long-term evaluation frameworks capable of linking workforce development to development impacts.

Sustainability is also threatened by workforce turnover, resource constraints and competing organisational priorities. APCOVE addresses these risks through simultaneous investment in practitioners, educators, institutions and regional networks. Partnerships with international organisations further strengthen sustainability and programme reach. For example, APCOVE is collaborating with the Food and Agriculture Organization of the United Nations (FAO) to host training resources on global learning platforms[5], while collaboration with Wildlife Health Australia[6] has enabled the adaptation of selected modules for wildlife-health professionals. Links with the Global Outbreak Alert and Response Network (GOARN)[7] further strengthen

connections between animal and human health sectors. These collaborations help ensure that training resources remain available, adaptable and relevant beyond the project's duration.

Capacity Development and Climate-Resilient Agro-Ecosystems

APCOVE II demonstrates how workforce development can strengthen climate-resilient livestock systems. As climate change alters disease distribution, seasonality and transmission patterns, veterinary professionals require the skills to detect emerging threats, assess changing risks and implement evidence-based responses.

This contribution is reflected in APCOVE's mentored field projects, several of which address climate-sensitive and transboundary animal diseases. For example, trainees have undertaken African swine fever outbreak investigations, applying epidemiological methods to identify risk factors for disease spread, evaluate biosecurity practices and support evidence-based control strategies in smallholder pig-production systems. These projects generate locally relevant evidence while strengthening practical epidemiological skills.

The programme's One Health approach further enhances resilience by promoting collaboration across animal, human and environmental health sectors. Faculty development, MEL activities and GEDSI integration help ensure that these capacities are sustained, adaptive and responsive to diverse community needs. Together, these investments strengthen the long-term ability of animal-health systems to respond to emerging disease threats in a changing climate.

Conclusions

The APCOVE II experience demonstrates that sustainable livestock systems depend not only on technological innovation but also on the capacity of people, institutions and networks to respond to emerging challenges. Through integrated training, workplace learning, One Health approaches, faculty development, MEL and GEDSI, APCOVE II strengthens adaptive capacity across animal-health systems.

Beyond disease preparedness, the programme highlights the importance of investing in human, institutional and social capital to build resilient livestock-based socio-ecological systems. Although developed for the Indo-Pacific, the APCOVE model has broader relevance for low- and middle-income regions facing similar constraints, including limited veterinary workforce capacity, endemic and emerging transboundary diseases, climate-related disease risks, and fragmented animal-health systems. These challenges are common across many parts of Africa and South America, where sustainable livestock development likewise depends on strengthening frontline epidemiology, interdisciplinary collaboration and institutional capacity. Future research should evaluate the long-term impacts of such investments on animal health, livelihoods, institutional performance and resilience.

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