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Financial Impacts of Foot-and-Mouth Disease at Village and National Levels in Lao PDR

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Summary

To assist policies on Foot-and-Mouth Disease (FMD) control in Laos and the Mekong region, the financial impact of recent outbreaks at village and national levels was examined. Village-level impacts were derived from recent research on financial losses due to FMD per smallholder household and number of households with FMD-affected livestock in the village. National-level impacts of FMD were determined from examination of 2011–2013 FMD reported to the Lao Department of Livestock and Fisheries (DLF), with the 2011 epidemic reported separately due to the large number and size of outbreaks of FMD in that year. Estimates of the national financial impact of FMD were based on (i) total FMD financial losses at the village level and (ii) the costs of FMD responses and other related costs at the DLF, provincial and district levels where FMD was reported, but excluding the costs of revenue forgone. A Monte Carlo simulation was utilized to account for likelihood of FMD over- and under-reporting. Foot-and-mouth disease was recorded in four provinces of Phonsaly, Bokeo, Xayabouli and Champasak in three consecutive years from 2011 to 2013. However, the FMD epidemic in 2011 was more widely distributed and involved 414 villages in 14 provinces, with thousands of cases of morbidity in cattle and buffalo and some mortalities. The estimated financial losses due to FMD in 2011 were USD 30 881 ($\pm 23\ 176$) at the village level and USD 13 512 291 at the national level based on the number of villages with FMD outbreaks reported. However, when the likelihood of FMD under-reporting was accounted for, the estimated financial losses at the national level could potentially increase to USD 102 094 464 ($\pm 52\ 147\ 261$), being almost 12% of the estimated farm gate value of the national large ruminant herd. These findings confirm that FMD causes substantial financial impacts in villages and to the national economy of Laos, providing justification for sustained investments in FMD control programmes.

Introduction

Lao People's Democratic Republic (Lao PDR or Laos) is a land-locked country located in the centre of the Greater Mekong Subregion (GMS), with a population of 6.3 million people in 2011 and a land area of 236 800 km² (FAO, 2012; World Bank, 2013). It is one of the smallest and poorest developing countries in the region, with agriculture as one of the most important economic sectors, contribut-

ing approximately 33% of the total national gross domestic product (GDP) and employing around 75% of the workforce in 2010 (OIE-FAO, 2012). Reducing rural poverty and enhancing food security remain a challenge in Laos where approximately two-thirds of the total population live in rural areas, with 74% of these people living on or less than USD 2 per day (World Bank, 2007) and an estimated one-third of the population undernourished (FAO, 2012; UNICEF, 2012).

Among the agricultural subsector, livestock production is increasingly important to the Lao economy, particularly in smallholder farm systems which remain undeveloped. Livestock provide up to 50% of smallholder household annual cash income and often serve multiple purposes, including wealth storage, the generation of fertilizer and cultural festivities (ADB 2005; Nampanya et al., 2010) and decreasingly, as draught animals. More than 94% of livestock products are produced by smallholder farmers (Wilson, 2007), and 58% and 78% of households with livestock own a herd size of four or less cattle and buffalo, respectively (Steering Committee for Lao Census of Agriculture, 2012). Constraints to optimal large ruminant production include limited availability of land, feed deficiency and, most importantly, endemic diseases including haemorrhagic septicaemia (HS) and Foot-and-Mouth Disease (FMD), the latter being the most important of transboundary animal diseases (TAD). Foot-and-Mouth Disease is of significant economic, trade and food security importance for a number of countries in the region, including Laos (Otte et al., 2004). Outbreaks of FMD have been recorded for many years throughout the country with recent epidemics dominated by FMD O serotypes (Perry et al., 2002; Khounsy et al., 2009; Rast et al., 2010; Nampanya et al., 2013a).

The Government of Laos (GoL) through the Department of Livestock and Fisheries (DLF) is responsible for animal disease management and control programmes in the country. With vaccines, funds and technical support from several donor agencies, the DLF has implemented various FMD control programmes in Laos, particularly in the northern region where socio-economic development still lags behind the central and southern regions (Epprecht et al., 2008; Government of Laos and the United Nations, 2009). The aim of this work was to achieve FMD freedom in South-East Asia by 2020 through the South-East Asia and China Foot-and-Mouth Disease (SEACFMD) programmes (OIE Sub-Regional Representation for South-East Asia, 2011). However, regional control of FMD is a major challenge, particularly in Laos as it shares borders with five other FMD-endemic countries and is positioned on a major thoroughfare for transboundary animal movements in the GMS from Thailand and Myanmar to China and Vietnam (Khounsy et al., 2008; Kerr et al., 2012). Gaining support from potential international donors, local governments as well as large ruminant smallholder farmers is crucial if FMD control programmes are to be successful in Laos. This support can be enhanced through improved stakeholder understanding of the financial impact of the disease on smallholders and at national and potentially regional levels.

Currently, reliable estimates of losses due to FMD in Laos have focused on smallholder households (Rast et al.,

2010; Nampanya et al., 2013b, 2014a). However, as there is a need to determine the financial impacts of the disease at the village and the national levels, this study aimed to determine estimates of these financial impacts as well as analyse the potential benefits to costs (BCA) of the FMD vaccination programme implemented in northern Laos between 2012 and 2016. This information is likely to assist the development of strategy and policy recommendations on sustainable FMD control in Laos and the GMS.

Methodology

Review of FMD outbreak records

Foot-and-Mouth Disease outbreak records between 2011 and 2013 that were available at the National Animal Health Centre of the Department of Livestock and Fisheries (NAHC-DLF) in Vientiane, capital city of Laos and the DLF regional office in Luang Prabang, were examined.

Financial impact of FMD at the village level

The FMD financial impact at the village level was determined using the financial losses per household and number of households with FMD-affected livestock in the village, excluding indirect financial impact of additional costs and revenue forgone (Dijkhuizen and Morris, 1997; Rushton, 2009); means, standard deviation and lower and upper 95% confident interval were determined. Data on financial losses per household were derived from studies in Laos between 2011 and 2013 involving 434 farmers and 44 villages with FMD-affected livestock, including unpublished and recently published findings (Nampanya et al., 2013b, 2014a). The FMD financial losses per household included those due to mortality (100% of pre-FMD sale value), production losses due to morbidity (difference between the expected sale price pre-FMD and 1 month following onset of FMD) and costs of treatment with medicines (Nampanya et al., 2013b; Table 1). To account for variation in the financial impact of FMD, a sensitivity analysis was performed to estimate losses if 50%, 75% and 100% of households with large ruminants in a village had been affected by FMD.

Financial impact of FMD at the national level

Due to the number and size of the FMD in 2011, the estimated financial impact of FMD at the national level in this study focused on 2011 data, using the model of total estimated financial impact of FMD in 2011 = (i) + (ii), where,

(i) total financial losses at the village level = the number of villages with FMD outbreaks reported in 2011 multiplied by the estimated cost of FMD per village (as

Table 1. Key input values of the financial impact of FMD at the village and national levels and FMD vaccination programmes in northern Laos

| Input value (Unit) | Value | Reference |
|---|--|--|
| Financial cost of FMD per household (USD/hh) | 727 | Nampanya et al. (2013b, 2014a) |
| No. households in village (hh) | 145 | Rast et al. (2010); Nampanya et al. (2013b, 2014a) |
| No. households with livestock (hh) | 67 | Rast et al. (2010); Nampanya et al. (2013b, 2014a) |
| No. households with FMD-affected livestock (hh) | 50 | Rast et al. (2010); Nampanya et al. (2013b, 2014a) |
| No. provinces with FMD recorded in 2011 | 14 (6 in northern Laos) | NAHC-DLF records |
| No. villages with FMD recorded in 2011 | 414 (146 in northern Laos) | NAHC-DLF records |
| No. villages that may have FMD but failed to report | 6271 (in 14 provinces) 2825 (in 6 northern provinces) | Steering Committee for Lao Census of Agriculture (2012) |
| DLF budget in 2011 (USD/year) | | Bastiaensen et al. (2011) and DLF records |
| National Animal Vaccination | 7125 | |
| Animal disease outbreak | 13 607 | |
| Establishment of FMD-free zone | 7125 | |
| Cost of administering a single FMD vaccination (USD/dose) | 2.1 | Nampanya et al. (2013a,b) |
| Incident outbreaks of FMD | 0.2 | Khounsy et al. (2008); Rast et al. (2010); Madin (2011); Nampanya et al. (2013a) |

hh, household; DLF, Department of Livestock and Fisheries; NAHC-DLF, National Animal Health Centre of the Department of Livestock and Fisheries.

described above) and (ii) the financial costs of FMD beyond the village level = the costs of FMD outbreak controls including vaccines and vaccination delivery, other related administrative costs at the DLF, plus the allocated budget for the veterinary divisions of the provincial and district offices where FMD was reported (Bastiaensen et al., 2011). However, these estimates excluded losses of revenue forgone from trade due to the difficulty in obtaining reliable data.

Monte Carlo simulation was utilized to account for the likelihood of over- and under-reporting of FMD using Microsoft Excel RAND function to generate random numbers and different outcomes in the model (Dijkhuizen and Morris, 1997). Total financial losses were determined in two scenarios: (i) the over-reporting scenario was determined from numbers of villages with FMD-affected livestock reported to NAHC-DLF and the distribution of those random numbers of villages with FMD-affected livestock, plus the estimated financial loss due to FMD per village; and (ii) the under-reporting scenario was determined from the distribution of those random numbers between the number of villages with FMD-affected livestock reported and the total number of rural villages in the provinces with FMD-affected livestock in the 2011 outbreaks (Steering Committee for Lao Census of Agriculture, 2012), plus the estimated financial loss due to FMD per village (Table 1). Multiple simulations were repeated where

means, standard deviation, and lower and upper 95% confident interval were determined.

Benefits to cost analysis of FMD vaccination campaigns

Between 2012 and 2016, the GoL through the DLF has received approximately 600 000–800 000 doses of FMD vaccine annually from the Stop Transboundary Animal Diseases and Zoonoses (STANDZ) programme funded from Australia and managed through the OIE (The Office International des Epizooties or the World Organisation for Animal health) Sub-Regional Representation for South-East Asia (SRR-SEA) and the OIE Japan Trust Fund. The donated vaccines have been used in northern Lao and administered through the DLF regional office in Luang Prabang.

To support and promote GoL policy on food security and poverty reduction in smallholder rural communities (Government of Laos and the United Nations, 2009; Ministry of Planning and Investment, 2011), including potential investment in TAD prevention and control programmes, the BCA of the FMD vaccination campaign in northern Laos was determined. Costs of the FMD vaccination programmes were obtained from the actual expenditure for 2012–2013, with costs for 2014 through 2016 based on budgeted allocation in the programme plan. The benefits of the programmes were determined based on the estimate

financial losses due to FMD in northern Laos (as described), with the FMD outbreaks in 2011 selected due to the extent and severity of the outbreaks (Nampanya et al., 2013a). Net present values (NPV) were determined by the difference between the total NPV of benefits and costs using a discount rate of 4.3% (Indexmundi, 2013). The benefit and cost ratio (BCR) was calculated by dividing the total NPV of benefits and costs (Dijkhuizen and Morris, 1997; Rushton, 2009). The analyses were based on the following assumptions: (i) FMD vaccines provide perfect protection for cattle and buffalo against FMD infection morbidity (reduced sale value and weight loss) and mortalities; (ii) cost of administering a single vaccination is USD 2.1 per animal (Nampanya et al., 2013a,b); (iii) no cattle or buffalo was used for draught; (iv) there was no salvage value for deaths of cattle and buffalo; (v) the sale price of live cattle and buffalo in northern Laos remains stable; (vi) the animals were free-grazing and had an annual daily weight gain of 100 g/day (Nampanya et al., 2014b); and (vii) that an FMD outbreak would occur every 5–7 years in the respective village (i.e. incidence of 0.2; Khounsy et al., 2008; Madin, 2011; Nampanya et al., 2013a).

Results

Review of FMD outbreak records

Foot-and-Mouth Disease records between 2011 and 2013 were tabulated (Table 2). The records showed that FMD occurred in the four provinces of Phonsaly, Bokeo, Xayabouli and Champasak in three consecutive years. Also, FMD in 2011 involved very large outbreaks, affecting 14 of the 17 provinces in Laos with 414 villages reporting cases of morbidity and mortality in cattle at 33 018 and 2747, respectively. The data also confirmed that December and March were high-risk periods for the occurrence of FMD infection. Laboratory analyses of 25 of 58 tissue samples from the 2011 outbreaks were positive for FMD serotype O (Myanmar 98 and Pan Asia topotype), and the rest of the samples were negative for any FMD serotypes.

Financial impact of FMD at the village and national levels

The estimated financial impact of FMD at the village level revealed losses of USD 30 881 ($\pm 23 176$; Table 3) per village. A sensitivity analysis showed if 50%, 75% and 100% of households with livestock in that village had been affected by FMD, the financial impact would be USD 19 578 ($\pm 12 226$), USD 29 367 ($\pm 18 339$) and USD 39 157 ($\pm 24 452$), respectively.

The national financial impact of FMD was estimated at USD 13 512 291 based on the reported number of villages with FMD-affected livestock. However, considering the likelihood of under-reporting of FMD, the 2011 FMD

outbreaks were estimated to have potentially caused losses of USD 102 094 464 ($\pm 52 147 261$) to the Lao economy (with 95% confidence intervals of USD 100 694 001 and USD 103 359 926; Table 2).

Benefit to cost analysis of the FMD vaccination programmes in the northern Laos

The estimated NPV of the FMD vaccination programme in northern Laos was USD 36 489 852 (Table 4) with a BCR of 5.3, indicating a potential economic benefit of USD 5.3 for every dollar invested in the vaccination programme.

Discussion

This study estimates of the national losses due to FMD during the recent 2011 epidemic in Laos as approximately USD 102 million, with a range of outcomes in the vicinity of USD 103.4 million and USD 6.4 million if scenarios of under- and over-reporting of FMD are considered. However, field observations indicate that over-reporting is very unlikely to have occurred. Further, as the selection process for sites and interviewees in the reference studies was necessarily based on convenience selection and farmer availability, caution is advised in interpretation of these findings.

The financial impact of FMD varies considerably between regions and countries and depends on a range of variables including the production system in which the disease occurs, the size and the degree of re-infection risks, the capacity of local authorities to respond to FMD during outbreaks (Kitching, 2002; Randolph et al., 2002; Knight-Jones and Rushton, 2013) and, importantly, the extent of the negative impacts on trade. Reported annual impacts of FMD in terms of visible production losses range from USD 35.0 million in Turkey to USD 2.3 billion in China, with the total financial losses in endemic regions worldwide estimated between USD 6.5 and USD 21.0 billion (Knight-Jones and Rushton, 2013). It is well known that the loss of trading opportunities due to trade restrictions on local and lucrative international markets that arise from TADs such as FMD may be much higher than the actual loss of livestock production, particularly in FMD-free countries (Perry et al., 2002; Rushton, 2009).

At the village level, the study found that FMD caused substantial financial impacts that were dependent on morbidity and mortality rates, numbers of FMD-affected households and costs of the animal treatment regimes adopted (Kitching, 2002; Nampanya et al., 2014a). In addition to the huge economic impacts of FMD on some affected communities, social impacts including mental health issues, changes in gender roles and reduced family welfare due to lost income and assets may accrue. The severity of socioeconomic impacts may be influenced not

Table 2. Summary of FMD recorded in Laos between 2011 and 2013

| Region and Province | 2011 | | 2012 | | 2013 | |
|---------------------|-----------|----------|-----------|----------|-----------|----------|
| | Outbreaks | Villages | Outbreaks | Villages | Outbreaks | Villages |
| North | 29 | 146 | 13 | 27 | 6 | 12 |
| Phongsaly | 7 | 25 | 3 | 3 | 1 | 1 |
| Luang Namtha | | | 2 | 11 | 2 | 6 |
| Oudomxay | 1 | 1 | | | | |
| Bokeo | 1 | 1 | 1 | 2 | 1 | 1 |
| Luang Prabang | 1 | 2 | | | | |
| Huaphanh | 11 | 82 | | | | |
| Xayabouly | 8 | 35 | 7 | 11 | 2 | 4 |
| Centre | 23 | 57 | 2 | 2 | * | * |
| Vientiane Capital | 20 | 44 | 2 | 2 | | |
| Xiengkhoung | | | | | | |
| Vientiane Province | 1 | 5 | | | | |
| Borikhamxay | | | | | | |
| Khammuane | 1 | 7 | | | * | * |
| Savannakhet | 1 | 1 | | | | |
| South | 16 | 211 | 1 | 2 | * | * |
| Saravane | 6 | 37 | | | | |
| Sekong | 4 | 6 | | | | |
| Champasack | 4 | 158 | 1 | 2 | * | * |
| Attapeu | 2 | 10 | | | | |
| Total | 68 | 414 | 16 | 31 | 6 | 12 |

*In late December 2013 and February 2014, a series of FMD outbreaks were reported in some villages in Khammune and Champasak Province although details of the outbreaks are not yet available.

only by the size and duration of the outbreaks, but also the vulnerability of the community (Buetre et al., 2013). Our studies identified that villages with a higher proportion of 'medium' and 'well-off' households were likely to recover more quickly from the negative impacts of an FMD outbreak than a 'poor' village, such as remote villages that are more reliant on incomes from the sale of large ruminants (Nampanya et al., 2014a). Poor households

often earn a larger share of income from livestock sales than well-off households, with the value of livestock assets being crucial for their household resilience and food stability as they can be readily sold when cash is required (Quisumbing et al., 1995; FAO, 2011; Nampanya et al., 2014a).

In many developing countries where animal health communication depends on passive surveillance information from low-capacity animal health services, accurate disease

Table 3. Estimated financial costs of FMD in 2011 at the village and national levels (USD)

| Variable | Mean (\pm SD) | 95% Confidence interval | |
|--|---------------------------------|-------------------------|-------------|
| | | Lower CI | Upper CI |
| No. households in village | 145 (\pm 91) | 118 | 172 |
| No. households with livestock | 67 (\pm 54) | 50 | 82 |
| No. households with FMD-affected livestock | 50 (\pm 42) | 38 | 62 |
| Financial cost of FMD per households | 728 (\pm 312) | 636 | 820 |
| Financial cost of FMD at village level (USD) | 30 881 (\pm 23 176) | 24 030 | 37 733 |
| Financial cost of FMD at national level (USD) | | | |
| A: Total FMD financial cost at village level | 12 784 734 | | |
| B: Indirect of additional losses | 727 557 | | |
| Total | 13 512 291 | | |
| Financial cost of FMD at national level in under-reporting of FMD scenario (USD) | 102 094 464 (\pm 52 147 261) | 100 694 001 | 103 359 926 |
| Financial cost of FMD at national level in over-reporting of FMD scenario (USD) | 6 353 494 (\pm 3 830 563) | 6 252 859 | 6 545 129 |

Table 4. Estimation of NPV and BCR of the FMD vaccination campaign in northern Laos between 2012 and 2016

| Years | 2012 | 2013 | 2014 | 2015 | 2016 | Total |
|----------|-----------|-----------|-----------|-----------|-----------|------------|
| Costs | | | | | | |
| 146 498 | 1 475 670 | 1 848 131 | 1 739 553 | 1 656 717 | 1 577 826 | 8 444 395 |
| Benefits | | | | | | |
| 0 | 9 670 776 | 9 210 263 | 9 027 149 | 8 679 951 | 8 346 107 | 44 934 247 |
| NPV | | | | | | |
| -146 498 | 8 195 106 | 7 362 133 | 7 287 596 | 7 023 234 | 6 768 281 | 36 489 852 |
| BCR | | | | | | |
| 0 | 6.5 | 4.9 | 5.2 | 5.2 | 5.3 | 5.3 |

prevalence estimates are unlikely to be achieved (Khounsy and Conlan, 2008; Vergne et al., 2012; Limon et al., 2013). Further, lack of institutional credibility and the conflicting priorities of the official veterinary service and smallholder farmers have been identified as barriers to prompt disease reporting (Limon et al., 2013). Our study used a simple Monte Carlo simulation with probability distribution to account for the likelihood of FMD under-reporting. Alternatively, a capture–recapture analysis for estimating the true number of villages that experienced FMD was used in the south-east province of Svay Rieng Cambodia and indicated that 46% of the total number villages in the province had experienced FMD (Vergne et al., 2012) could have been attempted. These approaches involve participatory epidemiology and are promoted in developing countries as they use a combination of practitioner communication skills and participatory methods to improve involvement of smallholder livestock keepers, assisting both the analyses of animal disease problems and evaluation of disease control programmes (Catley et al., 2012; Toribio and Rushton, 2012). Improving participatory epidemiological capacity in Laos may enhance both the quality and the quantity of disease surveillance and reporting, contributing to improved quality of future economic impact assessments of important TADs such as FMD.

As disease reporting and communications in Laos are generally ‘passive’, relying on awareness of its importance by local villagers and authorities (Khounsy and Conlan, 2008), it is considered very likely that the numbers of villages with FMD-affected livestock notified to the DLF in 2011 through 2013 were under-reported. Thus, an estimated financial impact of FMD in the 2011 outbreaks based on the number of villages with FMD-affected livestock reported to authorities is considered a gross underestimation of the true disease incidence. Further, despite accounting for the likelihood of FMD under-reporting (Khounsy and Conlan, 2008; Madin, 2011), the national-level estimate of the financial impact of the 2011 epidemic of approximately USD 102 million is also considered likely to underestimate the true cost of FMD as it excludes the

indirect additional costs and revenue forgone (Rushton, 2009; Knight-Jones and Rushton, 2013). Had other costs been included, such as lost trading opportunities and compromised future production due to changes in herd structure caused by infertility, the negative financial impact of FMD on the Lao economy would very likely be greater (Perry et al., 2002; Rushton, 2009). Nevertheless, considering the 2011 farm gate values of the national large ruminant herd of just under USD 850 million (Young et al., 2014) and the estimated annual export of large ruminants of about 100 000 head (Ministry of Planning and Investment, 2011), these estimated losses from FMD in 2011 were approximately 12% of the estimate farm gate value of the national large ruminant herd and indicated that the disease is of significant economic importance at both village and national levels in Laos.

The results of this study emphasize the importance of considering the economic impact of animal diseases such as FMD in TAD control programmes. However, it also implies that a more in-depth economic impact analysis that includes determination of indirect costs of the disease from revenue forgone, plus larger analyses that includes the outcomes of managing multiple diseases, is desirable. Determining the impact of TADs on national economies could be assisted by the use of social accounting matrix and computer general equilibrium methodologies. Complex simulation modelling could also be used to predict potential outcomes in future FMD outbreak events and assist with risk analysis. Of importance, efforts that achieve improved quality and management of disease reporting data from the district, provincial and national levels will result in improved quality of economic impact assessments of important disease including FMD.

The BCA analysis shows that the current of FMD vaccination programme is cost-effective and that every dollar invested potentially achieves USD 5.3 in benefits. The partial budget analysis at the smallholder farmer level indicated net benefits of biannual FMD vaccination programme of USD 22 and USD 33 for cattle and buffalo, respectively (Nampanya et al., 2013b). At the regional level, the annual

benefits of the FMD control programme in South-East Asia were estimated to exceed USD 70 million per year, with a benefit cost ratio of 3:1; considered to outweigh the costs of achieving FMD freedom by vaccination by 2020 (McLeod, 2010).

To achieve more effective TAD control, vaccination strategies should be supplemented with other disease control interventions, including improved animal movement control and quarantine, enhanced surveillance and reporting, plus public awareness campaigns that address FMD transmission risks (Windsor et al., 2011). Multiple interventions that improve large ruminant health and production and motivate interest in improved biosecurity (Nampanya et al., 2014a,b), in addition to the identification of FMD hot spots and the determination of the optimal number of vaccination rounds per year for smallholders, are highly recommended (Windsor et al., 2011; Nampanya et al., 2013a). This strategy may be more cost-effective in controlling FMD, particularly when compared to ring vaccination in the face of an outbreak, as the impact of using or not using ring vaccination is unpredictable. There is also a risk that vaccinators may transmit infection between herds (James and Rushton, 2002). Further, regular active surveillance such as 'negative FMD reporting', immediate reporting of suspected new cases of FMD with development of an emergency response capacity to more effectively manage and limit outbreaks, regular laboratory confirmation of isolates for vaccine matching, plus provision of funding and human resources, is critical in achieving the best FMD control strategies (Randolph et al., 2002; Windsor et al., 2011; Nampanya et al., 2013b). In FMD-endemic areas such as northern Laos, obtaining the trust of all stakeholders is critical for the support of vaccination programmes. Using high quality, efficacious FMD vaccines that are multivalent and compatible if necessary, plus regular examination of the field efficacy of the vaccine, usually by serological methods that differentiate infected from vaccinated animals (DIVA) during FMD outbreaks (Sutmoller et al., 2003; Rodriguez and Grubman, 2009), are desirable.

When considering the costs of FMD control programmes, the two economic concepts of public good and externality have emerged (Otte et al., 2004). These recognize that the outcomes of FMD control programmes will provide benefits to a large group of people (potentially everyone) who may not choose to incur the costs of the benefits achieved (Rushton, 2009). Further, the movement of live animals and animal products across boundaries may impose negative externalities such as the risk of FMD upon recipient and thoroughfare countries, which the country of origin and recipient as well as regional and international organization has some obligation to prevent or minimize (Otte et al., 2004). As Laos is a thoroughfare for animal

movement in the region (Kerr et al., 2012), there is justification for the FMD control needs of Laos to attract international public investment and collaboration. Assisting FMD control in Laos involves improving public veterinary and livestock extension capacities and should preferably include private investment. International donor support that enhancing large ruminant smallholder productivity and incomes via multiple interventions, plus assists development of village-level biosecurity programmes to reduce the risk of FMD and other TADs and support the policies of the GoL on poverty alleviation and improved food security in the region, is advised.

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