Final Draft

Realised and Potential Economic Benefits of the Southeast Asia Foot and Mouth Disease Campaign

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1. Summary

Foot and Mouth Disease (FMD) decreases animal production and is a contagious disease that can readily move across national boundaries. Livestock movement and trade in livestock products are restricted to restrict spread of the disease reducing the prices farmers in affected countries receive for their produce (Wilson and Kinsella, 2008, Jae Sun Roh et al 2006)¹ Trade restrictions and measures to eliminate the disease in newly infected countries inflict even larger economic costs than those attributable to animal production.

The OIE-South-east Asia Foot-and-Mouth Disease Campaign (OIE-SEAFMD) was established in 1997 to tackle the FMD problem in SE Asia and today is considered a model of regional cooperation in addressing a trans-boundary disease of this nature. The campaign has so far involved 8 countries – Thailand, Malaysia, the Philippines, Myanmar, Lao PDR, Cambodia, Vietnam and Indonesia and is supported by Australia and the Thai government, and more recently assisted by New-Zealand and France. Given the regional nature of infectious disease control, the Peoples Republic China has expressed an interest in joining the campaign. The costs and benefits of expanding the campaign to include more countries are not quantified in the report. This omission understates the potential economic benefits of FMD freedom in eastern Asia

Around \$US 4.4 million has been invested in SEAFMD since 1997 to support FMD control activities in the region. So far, the programme has helped in accelerating FMD elimination in the Philippines, albeit as a complimentary component of the AusAid assisted FAO program launched in this country during the late 1990s. Despite only five percent of the gross benefits of elimination in the Philippines being attributed to the SEAFMD investment, attributed benefits were calculated to cover the costs of the entire SEAFMD campaign to date.

FMD freedom using a vaccination-based approach is the ambitious long term goal of the SEAFMD campaign and requires that national programs adopt zone-based vaccination, movement control and surveillance strategies. The overall costs of activities to achieve elimination are estimated to be \$US 46 million per year until 2015², and then \$US 10 million per year until elimination is achieved in 2020. The estimated annual benefits to the region of more than \$US 70 million per year in terms of improved animal production, outweigh the costs of achieving FMD freedom.

Continued investment in the SEAFMD regional coordination unit is required to harmonise control activities, share information and provide technical assistance to member countries. A benefit cost-ratio of 3:1 was estimated for this investment, which indicates that for each dollar invested, three dollars of economic benefits will be generated.

¹ For example, during the first outbreak of FMD in Korea during 2000, prices for hogs, pork, and beef dropped 15-20% before government intervened (Jae Sun Roh *et al* 2006)

² Costs are estimated for current 8 campaign member countries, which includes Thailand, Malaysia, the Philippines, Myanmar, Lao PDR, Cambodia, Vietnam and Indonesia

2. Introduction

Foot and Mouth Disease (FMD) decreases animal production through impairing reproductive function, causing lameness in draft animals, and increasing mortality and weight loss in affected animals. These losses alone have been estimated to inflict substantial economic costs. For example, in India, FMD was estimated to cause \$1 billion per year (Saxena, 1994, Sing et al 2007) due to losses in draught power, animal death and costs of treatment.

Trade restrictions implemented to reduce the potential for disease spread and measures to eliminate the disease cause very large economic costs. The Productivity Commission in Australia estimated that an outbreak could cost as much as \$AUD 11 billion – largely due to markets closures, should an outbreak occur in this country. The European outbreaks in the early 2000s were calculated to cost more than \$AUD 12 billion in the UK. The disease is endemic in large parts of Southeast Asia, although FMD free zones are increasing in their geographic coverage. Indonesia together with central and southern Philippines and eastern Malaysia, are free zones for FMD and are faced with the challenge of maintaining this status. Given the transboundary nature of the disease, a regional approach is required to harmonize the surveillance systems, control measures, policies and legal framework between neighbouring countries. SEAFMD is such an approach.

The key objectives of the campaign are to achieve FMD freedom using vaccination by 2020 and maintain or extend FMD freedom in those countries and zones presently free of FMD. This vision has been articulated in a 2020 RoadMap, which provides a structured, yet flexible approach to achieving and maintaining FMD freedom in campaign member countries. To realise this vision the campaign provides its member countries with technical and financial support through eight components: (i) international coordination and support (through meetings, workshops and working groups), (ii) program management, resources and funding, (iii) public awareness and communication, (iv) policy, legislation and zoning, (v) surveillance, diagnosis and control, (vi) regional research and technology transfer (vii) private sector involvement and facilitation and, (viii) monitoring and evaluation.

In total, \$US 4.4 million (nominal terms) has been invested in the regional coordination unit and selected national programmes to achieve these objectives. To date, there has been no systematic assessment of the economic benefits from this investment, along with any future support for FMD freedom in the region. The objective of this report is to assess economic benefits of the program so far, and assess the net economic benefits of elimination over the 2011-2020 period.

The first section of this report outlines the major outputs of the SEAFMD campaign until 2011. Benefits of these outputs are then described by outlining the nature of the FMD problem in the region and key affected livestock production systems. Costbenefit analyses are presented for realised benefits and costs over the 1997 to 2010 period; a projection is made of costs and benefits of achieving FMD freedom as part of the 2020 RoadMap. There are a large number of data uncertainties and gaps associated with these analyses. A sensitivity analysis is presented in the final sections of the report to ascertain how robust results are to major assumptions.

3. SEAFMD Phases and their Outputs

The Southeast Asia Foot and Mouth Disease Campaign (SEAFMD) commenced in 1997 and the eight member countries are Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Thailand and Vietnam. The aim is to reduce the impacts of FMD on livestock owners, reduce poverty and to promote international trade in livestock and animal products in the region. The Campaign operates through a Regional Coordination Unit (RCU) in Bangkok that works in cooperation with the member countries and under the direction of the OIE Sub-Commission for FMD in Southeast Asia. A three phased approach was envisaged with the following components

SEAFMD commenced with a preparatory phase during which the various components necessary to initiate the control program were built. At the commencement of the program there was considerable disparity between participating countries in the base condition of their FMD control programs. Key elements of the first phase included capacity building and developing linkages with national programs. Resources were provided by AusAID, the Swiss Government supported a regional coordinator and the Government of Japan provided funds to support the annual meetings and workshops.

The development of a zoning approach enhanced public awareness and the increased FMD surveillance were major components of the campaign's second phase. Extensive epidemiological monitoring, strategic vaccination and the creation of disease-free areas were major activities undertaken over the 2001-2005 period. Major sources of finance included AusAID and New Zealand. Additional support was provided by France, OIE Japan Trust Fund, the Thailand Department of Livestock Development (DLD) and member countries.

"The review team concluded that the Regional Coordination Unit - Southeast Asia Foot and Mouth Disease (RCU-SEAFMD) has achieved international recognition as a model of excellence for regional coordination in animal health and in particular in Foot and Mouth Disease (FMD) control. RCU SEAFMD is providing a highly effective coordination role built around a clear regional strategy – outlined in the SEAFMD 2020 roadmap document - under which country activities can be planned and implemented in a way that ensures harmonisation, cooperation and working towards the shared vision. Donor agency and member country representatives are better able to identify potential project areas that contribute to member country needs, are aligned with the regional strategy, and link effectively and efficiently with activities of other donor agencies in the region. Progress is being made in capacity development in veterinary and diagnostic services with benefits directly attributable to FMD control as well as non-specific benefits for other diseases. In addition there is progress in regional FMD control and eradication with development of progressive zoning strategies, Indonesia maintaining freedom, Philippines successfully eradicating FMD and other member countries either reducing the incidence or developing animal health capacity. "

A final eradication and consolidation phase is now underway. This phase started in 2006 with a focus on consolidating national control and eradication programmes and further harmonising legislation for FMD control in member countries. The 13th Meeting of the OIE Sub-Commission recommended that Phase 3 be extended to December 2010 and that donors approached to support a campaign extension. Over the last 10 years the regional coordination function has received \$US 0.4 million per year and is supplemented by contributions for office accommodation, staffing and meeting costs by organisations such as DLD, Kasetsart University, member countries, OIE and the OIE Japan Trust Fund.

The RCU adds value to SEAFMDC by coordinating of epidemiological studies of FMD in the region, analysing information and advising on resultant FMD control strategies and using first-hand experience of FMD by international emergency management specialists and scientists. Key achievements to date include the development of first class scientific networks among the participating countries and, increasingly, with neighbouring countries such as China. Other achievements include: major improvements in laboratory, disease management and surveillance systems, the introduction of progressive zoning approaches, engagement of industry and enhanced public awareness and training. A major review was conducted of the current phase.

4. Realised and Potential Project Outcomes

There was considerable regional disparity in the capacity of national FMD programmes at the commencement of SEAFMD in 1997. While disparities still exist, the campaign has contributed to the harmonisation of reporting, control and surveillance of member countries. The regional FMD program is at a stage where improved knowledge has enabled a better understanding of hot spots and benefits of targeted vaccination. Such improvements have led to a decrease in FMD prevalence in some areas - decreasing the animal production impacts of the disease. The benefits of this outcome are presented in this section, firstly by reviewing livestock production in SE Asia and then outlining the nature of the foot-and-mouth disease problem.

4.1 Livestock Production in South East Asia

At a global level it is estimated that livestock accounts for 40% of total gross agricultural production and employs 1.3 billion people. Animal agriculture is also the main source of protein and other nutrients for 830 million food-insecure people, in the

form of meat or milk.

Livestock play an important role in the small-holder production systems of SE Asia. Cattle and buffalo are generally raised as part of mixed farming systems as a source of supplementary cash income, along with providing traction for sowing and ploughing fields.

A great deal of production occurs within backyard



production systems where animals provide an important source of cash for educating children and food security. At a regional level, the numbers of cattle and pigs are dramatically increasing. The demand for livestock products is increasing with population growth and increased meat consumption per head in many Asian countries.

FAO statistics show that meat demand has risen more dramatically across Asia than any other part of the world over the last 10 years. Pork is the dominant meat product in China, Vietnam, the Philippines, and South Korea. Pork consumption increased from less than 10kg per capita in the early-1990s, to a current consumption of 40kg per person in China and Taiwan. In response to this increase in demand, the supply of pig meat has dramatically increased in Vietnam and the Philippines. Pig production has substantial corporate backing in Thailand and is centred in the central plains areas and near to Bangkok.

FMD infection of pigs is less commonly observed than in bovines. Most FMD cases are reported in cattle. Cattle have been traditionally raised for draft and crop producing activities. Draft animals are frequently used for land preparation and manure output is incorporated as organic fertiliser. In the past, beef was commonly

derived from cast for age farm animals. With growing affluence there is increased demand for cattle of all ages, and the regional trade has been characterised by movement of cattle from central Myanmar into Thailand, Laos and Cambodia, then across to Vietnam

Of the countries included in the figure, Vietnam, Thailand, and Myanmar have the largest cattle



populations of 6 and 7, and 13 million head in 2008 respectively. Beef cattle production is the major form of cattle production within village-based systems using indigenous cattle breeds.

4.2. The Foot and Mouth Disease Problem

Foot and Mouth disease (FMD) is one of the most economically important animal health issues in South East Asia. When the SEAFMD Campaign started in 1997, there were three major FMD virus types identified in the region – O, A and Asia 1. Additional variants of Serotype O which include PanAsia and Cathay (pig adapted) have since been identified. Serotype O is considered as the most prevalent FMD virus and has recently caused major outbreaks in Vietnam, Cambodia, southern part of Lao PDR, some areas in Thailand and Malaysia.

Since 2001 around 0.4 million cases have been reported. FMD virus type O has been the predominate strain, being observed in half of all cases every year except in 2002. In the last five years many of the regional outbreaks have centred on Vietnam, with a large spike in 2006. The decrease in numbers of outbreaks in the Philippines and Thailand are also evident in the figure.



OIE note that no outbreak has been reported in the island countries of South East Asia since 2006. In the Philippines, no outbreak has been detected in Luzon since January 2006 and it has maintained Mindanao, Visayas, Palawan and Masbate as FMD Free

zones. Indonesia remains an FMD free country without vaccination and the zones in Sabah and Sarawak also remains free without vaccination. FMD is most commonly reported in cattle. The following figure illustrates the dominance of this species as a source of infection, when compared to buffalo and pigs. The large upsurge in 2006, was dominated by trade cattle moving



into Vietnam from Cambodia and Laos

Morbidity rates are generally higher in cattle and buffalo, when compared to pigs. Through the SEAFMD Campaign and active participation of member countries, tangible achievements have been attained in reducing the FMD outbreaks. The SEAFMD RCU report that no outbreak of serotypes Asia 1 and O PanAsia and Cathay were detected in the last two years. The challenge to the Campaign is to conduct more active surveillance to find out the remaining foci of these viruses so that future epizootics can be prevented

4.3. Benefits Associated with the SEAFMD Campaign and Improved Foot and Mouth Disease Management

The SEAFMD RCU provides technical and managerial inputs to support FMD control efforts in the region and provides a linkage through OIE to the national programs. This model of collaboration has been successful in other regions and with other diseases. For example, in South America, the Panaftosa Center has been critical to the success of the national programs that have achieved regional freedom from FMD and a co-ordinated program has been essential for the control of epidemic livestock diseases in Africa, such as rinderpest.

Through the SEAFMD Unit, donors have channelled support to integrate international animal health projects and avoid duplication and compartmentalisation of effort. SEAFMD collaborates with FAO and is linking with neighbouring countries such as Yunnan Province in the People's Republic of China in support of Upper Mekong Zone activities.

A roadmap toward FMD freedom by 2020 has been prepared and outlines the approach to vaccination, requirements for progressive zoning, and a means of strengthening capacities of national anima health services. The key beneficiaries of RCU activities are the animal health services in the region, who in term benefit livestock producers of the region. Key RCU benefits can be described in terms of reducing FMD prevalence and improving the income of farmers, environmental and gender empowerment.

Improvement of Small-holder Farmer Incomes

FMD affects animal production in many ways including increasing mortality, decreasing milk and meat production and causing lameness that prevents animals from being used for draught power to till land, harvest crops, or transport goods. Additional feed costs include feed costs needed during the longer than normal period of retention and costs of additional quality feed for improvement of animal health during the outbreak. The impact of FMD on small-holder farmers have been outlined for many of the SEAFMD member countries and elsewhere in Asia. Benefits from reducing the magnitude of the problem have also been estimated in a series of studies over the last twenty years.

Box 1: Selected FMD Impact Studies in Asia

- Laos. Following a widespread FMD outbreak in Laos during the late 1990s, a study observed that morbidity in buffaloes and cattle was as high as 100% and high mortalities were noted in susceptible young animals. Many farmers had to sell livestock at substantial discounts (half usual value). Draft animals infected during the cultivation period were often rendered lame. The survey observed that affected farms had to hire cattle and buffalo at a cost of 400 to 600 kg of rice per affected draft animal (Perry *et al* 2002).
- **Cambodia**. Maclean (2006) also found that FMD outbreaks during the cultivation season inflict substantial economic impacts on small holder farmers. The cost of infection during the wet season would be US\$34 per affected animal as farmers can't use affected stock for the whole cultivation season. This loss is considerable given average monthly income of a rural household in Cambodia is about US\$40.
- Vietnam. The widespread 2006 outbreak was investigated in Vietnam through case study interviews of 36 smallholder farms. Economic losses for severely affected farms ranged from US\$84 to US\$930, which is equivalent to 21% of total annual household income (Tung and Thuy 2007).
- **Thailand**. If FMD were to be eradicated from Thailand in 2010, the eradication would be economically viable, even without exports, with a predicted benefit-cost ratio of 3.73. With additional exports, the economic justification for control becomes much stronger with a benefit-cost ratio of up to 15:1 being achieved (Perry et al 1999)

Social Benefits

The loss of livestock due to FMD-related mortality, along with productivity losses associated with milk, meat and traction power reduce farmer income. Such losses can lead to financial stress. The Cambodian survey of McLean (2006) found that an average loss of \$US 34 per affected animal was evident, whereas overall income in rural household averages \$US 40 per year. Such acute financial burden can lead to depression and other psychological problems, which include cardio-vascular and sleep-related disorders. The widespread slaughter of affected livestock and social stigma associated with an outbreak also causes stress. The reduction in regional FMD prevalence as a result of SEAFMD will decrease this impact, and generate social benefits.

5. Benefit-cost Analysis of the SEAFMD Campaign

Two economic analyses are conducted to examine the economic benefits of SEAFMD investment. The first assesses economic benefits between 1997 and 2010. Costs and in-kind support provided by donors and the Government of Thailand are related to these benefits and the net benefits of the investment so far calculated. Secondly, the costs of achieving FMD freedom as stated in the 2020 Roadmap are calculated. They are specified for national programs, and also for regional coordination and management. Benefits of FMD elimination are then compared to costs and the economic attractiveness of prospective investment from 2011 to 2020 calculated. The section is concluded with a presentation of cost-benefit analysis results and sensitivity analyses.

5.1. Evaluation of the SEAFMD Campaign until 2010

5.1.1. Realised Benefits from the Philippines

Support for the regional RCU commenced in 1997 and has been sustained over the last thirteen years across three phases. Key outputs include an enhancement in regional technical networks, improved surveillance capacity and improved management of national programs in member countries. The benefits of coordination are typically hard to quantify as the 'without' investment scenario is sometimes difficult to quantify, along with the value of enhanced capacity and improved information being not readily tangible. A key outcome of improved management since commencement of the campaign have been accelerated elimination of FMD from the Philippines in conjunction with AusAid financed FAO support of the national program. This benefit is quantified in this section.

Reduced Incidence of FMD in Philippines Swine

The incidence of FMD is less in pigs, when compared to cattle. Pigs, however, are susceptible to infection and cases are recorded throughout the region. During the 1990s there was a serious outbreak of pig-adapted FMD in the Philippines. In 1995, the Philippines FMD Task force recorded more than 1,500 outbreaks in this year. Industry estimated the annual cost of this outbreak to be \$95 million. The cost comprised elevated production costs, as pigs could not be marketed during outbreaks, treatment costs and morbidity and mortality costs. This cost is assumed to decrease in proportion to the number of cases recorded per year until FMD was eliminated in 2004.

The establishment of the RCU is assumed to have accelerated the speed of elimination and decrease the annual reported case load by 5%, then otherwise would have been the case without international support. Consequently, around \$US 1 million per year in benefits are attributed to the RCU during the 1990s, and this decreases to about

\$0.2 million per year in the early 2000s. Since elimination, in 2004, no benefits are attributed to SEAFMD. Conceptually it could be argued that improved regional coordination is decreasing the probability of re-introduction. This benefit is explored in the sensitivity analysis, but not in baseline calculations of benefits.

Parameter	Value	Source
Cost of the FMD outbreak in Philippines swine in 1995	\$95 million	Industry estimate
Reduction in outbreaks	Outbreaks reduced from 1556 in 1995, to 421 by 1997, then elimination by 2006	Philippines FMD Taskforce. Consultant assumed industry costs are proportional to reported outbreaks.
Proportion of reduction attributed to SEAFMD	5%	Consultant estimate. Net cost reduction attributed to the campaign

 Table 1: Economic Analysis Assumption Summary Table

5.1.2 Results to Date

Economic benefits and costs over the 1997 to 2010 period are presented in the adjoining figure. It is evident that the campaign has generated greatest economic benefits in the Philippines. The net present value (NPV) of the SEAFMD campaign

so far is estimated to be \$US 1.7 million expressed in 2010 dollar terms and at a discount rate of 5%. The NPV is calculated by subtracting costs from estimated benefits, discounted through time.

The corresponding benefit-cost ratio was estimated to be 1.2:1 and the internal rate of return 7%. The benefit-cost ratio is simply the ratio of

benefits costs. Based on the calculation, a total of \$US 1.2 in benefits has been generated from SEAFMD investment. It is difficult to attribute regional costs to each country, as much of the investment has involved coordination, regional meeting, training and capacity development. Consequently all campaign costs are included in the cost-benefit analysis.

Based on the assumptions used in the analysis, it is estimated that the costs of the SEAFMD campaign are less than the benefits of improved coordination that the investment has generated. Much of the investment over the first phases of the campaign has provided a foundation to move forward and eliminate FMD from the region. Elimination will require a significant increase in national program expenditure. These costs are outlined in the next section, along with the benefits of reduced impacts of FMD on animal production and improved trade in livestock products.

5.2. Economic Benefits of the Roadmap

The SEAFMD 2020 Roadmap was endorsed by the OIE Sub-Commission in March 2007 and by the OIE Regional Commission during its General Session in May 2007. Given the limited resources of member countries and geographic considerations, a key strategic element of the SEAFMD 2020 Roadmap is to progressively control FMD using a step-by-step approach. Previously, the regional cost of vaccination and enhanced veterinary services to eliminate FMD were estimated to be nearly \$US 400 million per year. This level of expenditure does not reflect a zoning approach.

In this section, the costs of vaccination, animal movement control, improved surveillance and program management are outlined using a stepped approach to elimination. The benefits of this revised approach are mapped against costs to determine whether such a strategy is economically attractive.

5.2.1 National and Regional Costs of FMD Control

The mass control approach, which was the previous strategy adopted by SEAFMD

during its initial stages, has been found to be unrealistic due to huge resources needed. As part of the 2020 Roadmap, a progressive zoning has been adopted and ensures effective use of limited resources from the donors and national governments. The map has the major objective of reaching the targets for FMD freedom with vaccination in 2020.

Figure 6: Costs of the Road Map by Country Source: Consultant

The costs of the Roadmap over the 2011-2020 period are estimated and provided in the Appendix. Key components of the plan include management and coordination, vaccination, surveillance, outbreak and response, and animal movement control. Costs are presented for each country and also for a regional coordination unit. This breakdown is presented in the adjoining figure. It is evident that Vietnam, Thailand and Myanmar have the largest resource needs. This is due to the large cattle populations in each of these countries. The Roadmap includes resources required to eliminate FMD in cattle, as commercial pig producers are assumed to be primarily responsible for vaccination, and pigs are less important in transmission.

	Enhanced Coord-	Vaccination	FMD Surveill-	Outbreak &	Animal Move- ment	
Component	ination	Strategy	ance	Response	Control	Total
I. Investment Costs						
A. Equipment	-	26,000	-	-	-	26,000
B. Technical Assistance	1,000	-	-	-	-	1,000
C. Meetings, Training	4,400	1,733	400	1,200	-	7,733
D. Public Awareness	700	-	-	-	-	700
E. Research	4,000	-	1,600	-	-	5,600
F. Management and M&E	2,180	-	-	-	-	2,180
Total Investment Costs	12,280	27,733	2,000	1,200	-	43,213
II. Recurrent Costs						
A. Vaccines	-	130,000	-	-	-	130,000
B. Animal Identification	-	-	-	-	65,000	65,000
C. Operating Costs	1,000	10,920	16,000	11,400	7,650	46,970
COSTS	13,280	168,653	18,000	12,600	72,650	285,183

Table 2: Overall costs of Roadmap (2010-2020) (\$'000)

Vaccination and animal movement control are the major components of the Roadmap by cost. Nearly half of the overall plan cost can be attributed to vaccination. Animal identification as part of movement control is the next most important cost item. Regional coordination is assumed to remain at current levels of around \$0.5 million per year. Consequently, this cost is only a minor portion of overall costs of achieving FMD elimination in SE Asia. Each element of the plan is subsequently described.

Box 2: Elements of the 2020 RoadMap

• Enhanced Coordination and Management. This component of the Roadmap represents less than 5% of overall costs. Supporting national veterinary services, so that their diseases surveillance and control systems comply with the OIE International Standards, is a major part of this component. Such activities ensure the early detection, rapid response and containment of any occurrence of contagious disease, including FMD. Key costs include support for the regional unit, meetings, technical assistance, monitoring and evaluation and public awareness.

- Vaccination Strategy. Vaccines account for around half of all Roadmap costs. Large cattle herds in Vietnam, Thailand and Myanmar require these countries have large vaccination programs to ensure elimination. Currently Myanmar and Thailand have a capacity to produce FMD vaccine. Thailand has a modern plant for bivalent or trivalent vaccines to meet requirements of the cattle and buffalo vaccination programs. The plant in Myanmar requires refurbishment and produces limited vaccine. Other countries in the region import vaccines for current needs. Development of a vaccine with additional antigens to confer protection against other major diseases would provide substantial encouragement to animal holders to participate in vaccination programs.
- **Improved Surveillance**. Improved surveillance comprises around 6% of overall Roadmap costs. There is need to support implementation of laboratory networks to provide the information base required for vaccine selection and progress monitoring, as well as investment in basic surveillance in each

country. The origins of FMD epizootics in the region are not understood, and insufficient investigations are currently undertaken to develop a scientifically-based understanding of the local and regional epidemiology of the disease.

- **Outbreak and Response**. Key activities in this component include supporting response teams, providing compensation during the later stages of elimination, disinfection of affected farms and slaughter houses and the training of field epidemiology staff. This component accounts for less than 5% of overall Roadmap costs.
- Animal Movement Control. More than a quarter of resource needs are targeting animal movement control. With the exception of the Philippines, all the countries in the program area have open borders with one or more neighbours, and most international livestock movements take place illegally. The direction of the movement is dictated by the supply and demand principles of the marketplace. Currently beef cattle move from Myanmar across the regions towards Vietnam, and pig meat travels the opposite direction. The Roadmap will facilitate the development of bilateral protocols that encourage legal movement of animals and minimise the risk of disease spread. A system is required to also monitor animal movements. Animal identification is required as part of this development and accounts for 23% of all Roadmap costs.

5.2.2 Benefits of FMD Elimination in SE Asia

Adoption of the Roadmap will require significant front end expenditure, as vaccination efforts will be most intensive during the first years of implementation.

Between 2011 and 2015 it is estimated that the campaign would cost \$46 million per year, and then decrease to around \$10 million per year. The sequencing of the stages of vaccination will

follow priority zoning. The estimated cost stream, depicted in blue, is presented in Figure 8. The animal production benefits and trade benefits of achieving elimination of FMD from the region are also included in the figure. Animal production benefits are estimated for beef cattle and swine industries in member countries.

Benefits of Reduced incidence of FMD in Beef Cattle

Myanmar, Vietnam and Thailand have the largest cattle herds in the region, and are increasing in size with higher demand for livestock products. Actual FMD prevalence is difficult to estimate as there is considerable under-reporting in the region, and outbreaks occur on a sporadic basis. In Myanmar, which has the largest national cattle herd; there is a large variation in FMD seroprevalence.

Within some of the central states, seroprevalence of 40% has been observed, and outbreaks occur every few years (Kyaw, 2010 personal communication). Conversely, seroprevalence in southern states have been found to be zero. An average national symptomatic prevalence of 3% is included for higher prevalence countries to estimate current production losses. Higher prevalence countries include Cambodia, Thailand, Vietnam and Myanmar.

Parameter	Value	Source
Current cattle populations		FAO database. Numbers in
Cambodia	3.4	millions. Average annual growth
Indonesia	11.9	rates were projected until 2020
Laos	1.5	base on growth in cattle numbers
Malaysia	0.8	over the last 5 years for each
Myanmar	12.9	country.
Philippines	2.6	
Thailand	6.7	
Vietnam	6.4	
Current annual prevalence of	3%	Consultant estimate based on OIE
symptomatic FMD in cattle high		reporting, and discussions with
prevalence countries		technical specialists. Countries
·		include Cambodia, Myanmar,
		Thailand, and Vietnam
Current annual prevalence of	1%	Consultant estimate based on OIE
symptomatic FMD in cattle low		reporting, and discussions with
prevalence countries		technical specialists. Countries
		include Laos and Malaysia
Decrease in FMD prevalence	Linear	Annual prevalence was decreased
		on a linear basis for each country
		so zero prevalence was reached in
		2020
Average farm-gate price for cattle	\$1 per kg	Taken from discussions with
		country teams and FAO online
		database
Percentage of year end cattle	12%	Taken from FAO
slaughtered per year		
Treatment cost for FMD infected	\$2 per head	Taken from discussions with
stock		experts
Proportion of cattle treated	30%	Consultant estimate
Proportion of cattle used for draft	40%	Taken from Harrison and Tisdell
		(2000) and discussions with
		experts. The proportion was held
		constant from 2011 to 2020.
Traction days lost per case	30 days	Assumes FMD incidence affects
		animal for 30 days. Assumes major
		outbreaks are in middle of
		cultivation season
Cost per lost day of draft power	\$3 per day	Taken from discussions with
		experts. Cost is the daily price of
		hiring a draft cattle team
Cattle case fatality	1%	Consultant estimate based on
		discussions with experts. Young
		cattle are primarily affected, with
		mature case fatality very low
Cost of weaner cattle	\$200 per	Consultant estimate
	animal	

Table 3: Economic Analy	sis Cattle Assum	ption Summary Table
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Cattle producers capture benefits though avoiding FMD treatment, having cattle with higher weights at sale, and lower numbers of draft animals incapacitated during the cultivation season. In the case of draft animals, it is assumed that 40% of cattle in Myanmar and Cambodia are used for cultivating crops. In much of the region power tillers are replacing animal power, however in these two countries bullock teams are still widely used in crop production. It is estimated that an average infection reduces

a farmers days of animal traction by 30 days. The actual numbers varies according to when in the planting season an outbreak occurs. If the outbreak were to be at the beginning of cultivation, months of animal power could be lost, whereas an outbreak late in the season would result in a couple of weeks of lost availability of an animal. It is assumed that the cost to the farmer stems from having to hire other livestock to prepare fields. This costs an average of \$3 per day for a team of bullocks.

The treatment of affected stock varies as to whether traditional or veterinarians are engaged. Traditional treatment may cost around \$0.1 per animal, whereas veterinarians supported administration of antibiotics is around \$5 per case. An average of \$2 per treated animal is included, and it is assumed that 30% of cattle (mainly draft) are treated.

Morbidity costs are limited to reduced live weight at marketing, as dairy production is only limited across the region. It is estimated that an FMD affected animal would, on average, have a 10kg reduced weight at marketing than would have been the case in the absence of infection. This weight loss is valued at \$1 per kg. A low case fatality rate is also included and the value of cattle included in estimating mortality costs.

As a result of adopting the Roadmap it is assumed that the number of cases of FMD will decrease linearly until there is no FMD in 2020. The value of reduced numbers of FMD cases in cattle is compared to a projection of FMD impacts at current FMD prevalence. National cattle herds are assumed to increase in size at an average rate equivalent to growth over the last five years in each respective country.

Reduced Incidence of FMD in Swine

As already noted, the incidence of FMD is considered less in pigs (Chamnanpood *et al* 1995) when compared to cattle. Similarly to cattle, the assumptions about weight loss, value of affected production and reduced number of cases as a result of adoption of the Roadmap are outlined in the summary table. Vietnam, the Philippines and Thailand are included in the analysis, as these countries have the largest national pig herds and commercial producers with capacity to implement a widespread vaccination strategy. It should be noted that pig-related vaccination is assumed to be covered by the private sector, and no vaccination costs have bee included in the \$46 million per year resource need until 2015 outlined in the previous section describing costs of the Roadmap.

Parameter	Value	Source
Current swine populations		FAO database. Numbers in
Philippines	13.1	millions. Average annual growth
Thailand	7.8	rates were projected until 2020
Vietnam	26.7	base on growth in pigs over the last
		5 years for each country.
Current annual prevalence of	1%	Consultant estimate based on OIE
symptomatic FMD in pigs high		reporting, and discussions with
prevalence countries		technical specialists. Countries
		include Cambodia, Myanmar,
		Thailand, and Vietnam
Current annual prevalence of	0.5%	Consultant estimate based on OIE
symptomatic FMD in pigs low		reporting, and discussions with
prevalence countries		technical specialists. Countries
		include Laos and Malaysia
Weight loss in infected stock	5 kg	Taken from Harrison and Tisdell
		(2000)
Average farm-gate price for pigs	\$1.5 per kg	Consultant estimate
Case fatality for pigs	10%	Case fatality in weaners Estimate
		following discussions with
		Philippines Task Force
Cost per weaner	\$40	Consultant estimate
Cost of treatment	\$2 per head	Cost of treatment per case
Private vaccination	\$5 million per	\$2 million per year in Thailand until
	year until	2015, then \$0.25 million. For
	2015, then	Vietnam, \$3 million, then \$0.4
	\$0.7 million	million per year.
Exports from FMD-free zones	10,000 tonnes	Taken from Perry et al (1999).
capturing premium		5000 tonnes for Thailand and 5000
		for the Philippines
Price premium for FMD-free	\$2 per kg	Consultant estimate derived from
exports		Perry et al (1999) and Randolph et
		al (2002)

Table 4: Economic Ana	alvsis Swine Assum	ption Summary Table

FMD-Free Zone Status and Enhanced Value of Exports

In addition to animal production benefits, the development of FMD-free zones could facilitate the access of producers in SE Asia to higher priced markets for livestock products. Perry et al (1999) and Randolph et al (2002) estimated that 5000 tonnes of chilled pork could be shipped from the Philippines and Thailand respectively (10,000 tonnes in total) at a net benefit of around \$2 per kg. Based on these prices and volumes, and assuming exports from these countries do not influence global prices, FMD elimination could generate gross benefits for Thailand and the Philippines of \$20 million per year. This benefit stream is included as a scenario in assessing the economic attractiveness of implementing the Roadmap

5.2.3 Projected Results of Road Map Implementation

The gross economic benefits of animal production benefits increase over the 2010-2020 period as the numbers of cases cumulatively decrease until elimination of FMD is achieved. Avoided animal traction loss costs in Myanmar are the largest economic benefit of this reduction in prevalence. The overall benefit surpasses \$60 million per

year by 2020, while the benefits of accessing international markets are held constant at \$20 million per year. A proportion of these benefits can be attributed to supporting the regional coordination unit. For the purposes of this cost-benefit, it is assumed that 5% of regional benefits can be attributed to such coordination, as the largest share of benefits need to be attributed to national programs that would implement the Roadmap.

The net present values (\$US million, in 2010 terms) of SEAFMD regional coordination is presented in the Table 5, along with other investment criteria. As already reported the benefits of improved management in the Philippines have covered the costs of the program to date. It is evident that a net present value of \$1.7 million is calculated.

Investment criteria	Benefits between 1997-2010	Projected (animal production) 2010-2020	Projected (animal production & trade) 2010-2020
Present Value of Costs (\$m)	6.8	4.6	4.6
Present Value of Benefits (\$m)	8.5	6.5	14.3
Net Present Value (\$m)	1.7	1.9	9.7
Benefit–Cost Ratio	1.2	1.4	3.1
Internal Rate of Return (%)	7.1	na	29.5

Table 5: Investment Criteria

When only animal production benefits are considered in the projected scenario, the net present value of supporting SEAFMD regional coordination is \$1.9 million. Within this scenario all countries are assumed to capture reduced animal treatment costs, less meat losses and reduced traction costs. Based on assumptions included in the study, a reduction in traction losses in Myanmar is the major economic benefit. The large cattle herd in this country and widespread use of traction underpins this high estimated benefit for this country.

Trade benefits are included for Thailand and Philippines in the third scenario (last column of table). These benefits are added to animal production benefits. It is evident that the NPV of achieving freedom increases from \$US 1.9 million to \$US 9.7 million. This result increases that animal production benefits are just sufficient to cover that high cost of achieving FMD freedom across current SEAFMD member countries. The addition of trade benefits greatly improves campaign economic attractiveness. The benefit-cost ratio of the trade scenario is 3.1:1, which suggests that future investment in SEAFMD would generate three dollars for every dollar invested. These benefits and costs are contingent on funds being invested in national programs to support the Roadmap, and that vaccination-based control leads to FMD freedom by 2020.

5.3. Sensitivity Analysis

A number of estimates have been included in the analysis in relation to economic attractiveness of supporting SEAFMD regional coordination. These estimates have been made using the best available information, but are uncertain. Sensitivity analysis is undertaken in this section to determine which parameters have a significant impact upon the estimated economic returns of the campaign.

5.3.1. Estimated FMD Prevalence

FMD prevalence's of 3% and 1% were included in the analysis for baseline economic return calculations. There is considerable uncertainty to the exact order of FMD given current under-reporting. Consequently, the sensitivity of net present value and benefit-cost ratios to this assumption are outlined in Table 6.

Investment criteria	FMD Prevalence 50% of Baseline	Projected (animal production) Baseline	FMD Prevalence 200% of Baseline
Present Value of Costs (\$m)	4.6	4.6	4.6
Present Value of Benefits (\$m)	-3.1	6.7	26.1
Net Present Value (\$m)	-7.7	2.0	21.5
Benefit–Cost Ratio	-0.7	1.4	5.6
Internal Rate of Return (%)	na	na	51.6

Table 6: Sensitivity³ of Investment Criteria to FMD prevalence

If prevalence was double that assumed in the animal production baseline scenario, then the benefit-cost ratio would increase to 5.6:1 and net present value to \$22 million. A doubling of symptomatic prevalence would result in an assumed prevalence of 6% in cattle of higher prevalence countries. Given sero-prevalence of 40% has been observed in large cattle producing states of Myanmar, a prevalence of this order is possible. A conservative estimate was included in the analysis given the uncertainty surrounding the magnitude of this key parameter.

5.3.2. Attribution of Benefits to SEAFMD Campaign

A 5% attribution rate was included in the analysis for baseline economic return calculations. The appropriate magnitude of this parameter is difficult to define with accuracy. Enhance coordination and improved information is inherently difficult to quantify as they are intangible and it is not apparent what would have happened in the

³ A range of input values are included in the sensitivity analysis to gain an appreciation for how robust results are to key assumptions included in the cost-benefit analysis.

absence of the investment being made. Consequently, a conservative estimate is included in the analysis. If 10% of benefits of the animal production and trade scenario were attributed to SEAFMD, then the net present value would increase to \$24 million

Investment criteria	1% of Benefits Attributed to SEAFMD	5% of Benefits Attributed to SEAFMD	10% of Benefits Attributed to SEAFMD
Present Value of Costs (\$m)	4.6	4.6	4.6
Present Value of Benefits (\$m)	2.9	14.4	28.9
Net Present Value (\$m)	-1.7	9.8	24.2
Benefit–Cost Ratio	0.6	3.1	6.2
Internal Rate of Return (%)	na	29.8	37.8

Table 7: Sensitivity of Investment Criteria to Attribution*

* Animal production and trade scenario

5.3.3. Benefits to Other Countries

FMD is a highly infective virus and removing a potential reservoir of infection in SE Asia will have benefits for countries in the region that are currently free of disease. The "One World, One Health" concept recognizes the Global Public Good nature of investment in the effective control of infectious diseases that do not respect national or economic boundaries and impose high costs. Countries such as Indonesia and the Philippines who have recently eliminated the virus have a reduced probability of reinfection, while neighbours such as Australia have a lower chance of incursion.

The introduction of the virus into Australia would generate very large economic costs for that country in the forms of reduced market access and freeing the country from FMD. The AUSVETPLAN (Animal Health Australia, 2001) has been developed to

minimise the impacts of an FMD outbreak. Key elements of the plan include quarantine, slaughter and decontamination. The costs of implementing such a plan, along with trade costs were modelled by the Australian Productivity Commission in 2002. FMD was estimated to cost between \$AUD 2.5 and 11 billion depending on the size of the outbreak.

The probability of FMD being introduced is difficult to determine, although increased mobility and trade is possibly making the chance higher. For the purposes of the analysis it is assumed that the annual probability of a small outbreak is 0.75% and 0.25% for a large outbreak.

On a probabilistic basis, the

Box 3: Scenarios of Economic Impacts of FMD in Australia

- Small outbreak. This involves a single outbreak in Western Australia in the wheatsheep zone. It includes 38,000 animals being culled during an eradication campaign lasting about 8 weeks. FMD was estimated to cost the country around \$US 2.5 billion.
- Medium-sized outbreak. This outbreak was assumed to commence on a large extensive beef property in Queensland. This scenario, having duration of 13.2 weeks, was estimated to cost the Australian economy around \$US 4.0 billion.
- Large-sized outbreak. It was assumed that the outbreak would last 33 weeks. There would be an average of 211 infected premises and 750,000 animals would be destroyed – costing \$US 11 billion.

average annual cost is around \$40 million per year. If the successful elimination of FMD from SE Asia could reduce the probability of an introduction into Australia by 50%, then the net present value of investing in the SEAFMD coordinating unit would be \$18 million⁴. This increase represents a doubling of net present value over the animal production and trade benefits scenario. Other countries in Asia, North

⁴ Estimate includes trade and animal production benefits. Benefits to 'other' countries are estimated for Australia, due to the availability of economic impact data. Annualized benefits account for a relatively low probability of incursion, and a medium sized out-break assumed. A large scale outbreak was estimated to cost as much as \$AUD 13 billion (\$US 11 billion).

America, Europe and Africa could also benefit from elimination of FMD from SE Asia. These benefits are not included but would be substantial.

Investment criteria	Base	50% Reduced probability of an Australian outbreak	75% Reduced probability of an Australian outbreak
Present Value of Costs (\$m)	4.6	4.6	4.6
Present Value of Benefits (\$m)	14.4	22.2	26.0
Net Present Value (\$m)	9.8	17.5	21.4
Benefit–Cost Ratio	3.1	4.8	5.6
Internal Rate of Return (%)	29.8	64.8	100.9

 Table 8: Sensitivity of Investment Criteria to Overseas Benefits

6. Conclusions

The benefits of enhancing the response of the Philippine national FMD programs to outbreaks in the last 1990s, and improving coordination of the Thai response to the Myanmar Asia-1 outbreak have covered the costs of investment to date in the SEAFMD regional coordination unit. Adoption of the 2020 Roadmap and elimination of FMD from SE Asia by 2020 would also generate considerable economic benefits for the region. If only 5% of these benefits could be attributed to regional coordination, then investment in SEAFMD would generate an economic benefit of \$US 3 for every dollar invested.

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