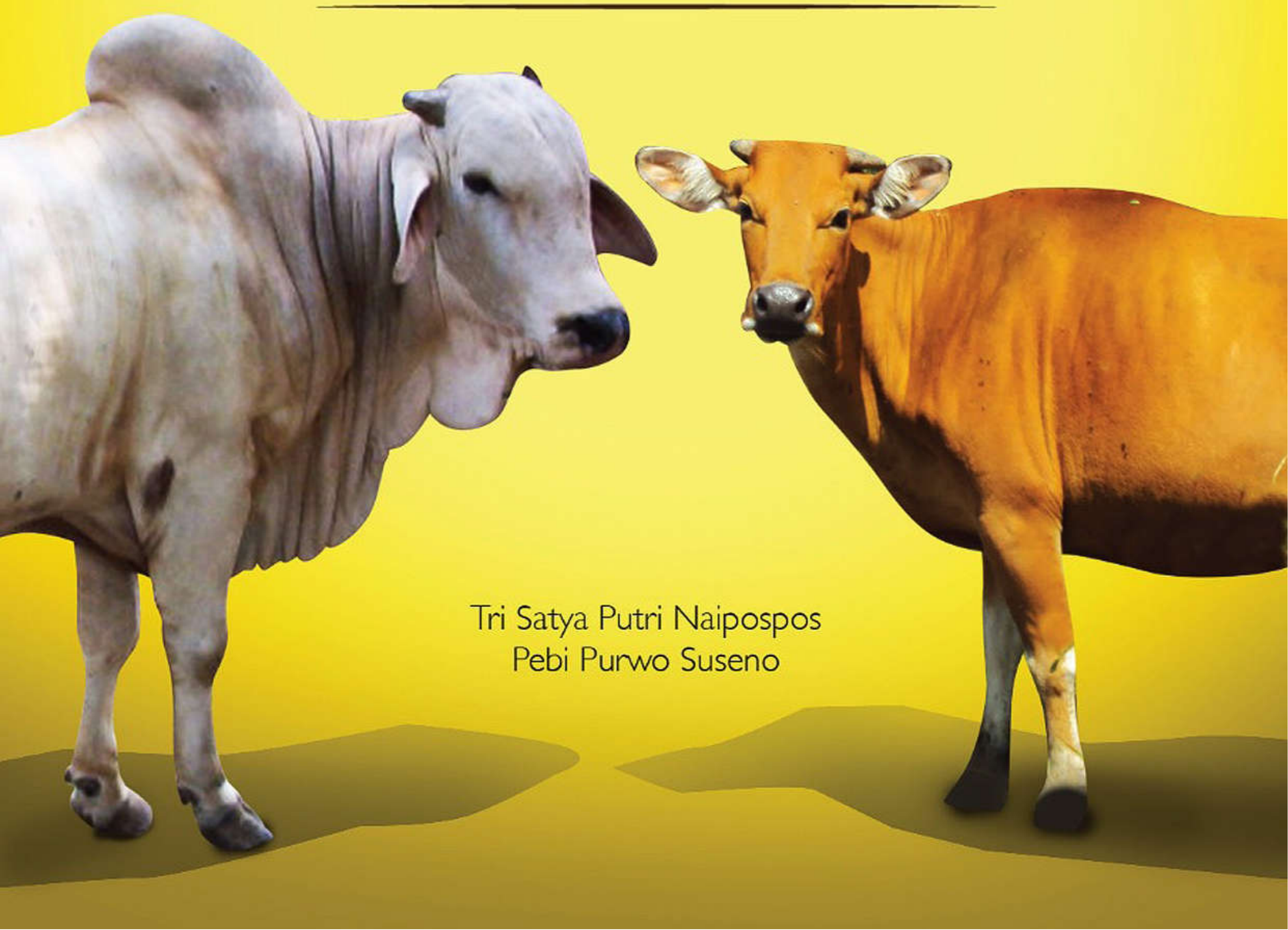
World Organisation for Animal Health

COST BENEFIT ANALYSIS of

Maintaining **FMD** Freedom Status in Indonesia



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A report submitted to
the World Organisation of Animal Health (OIE)

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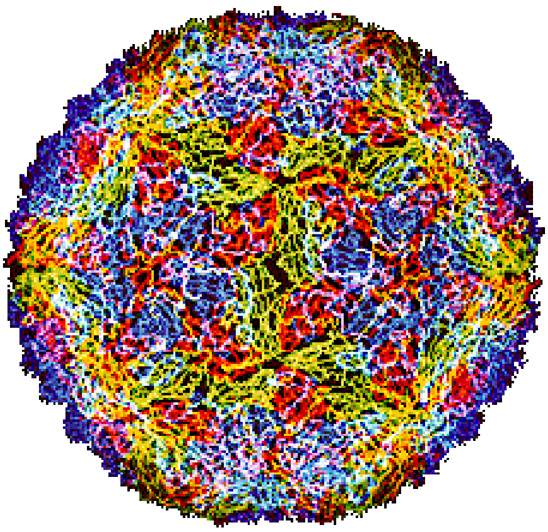

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Preface

Praise to God the Almighty for His Blessings and Grace, the report on Cost Benefit Analysis for Maintaining FMD Freedom Status in Indonesia has been completed.

Foot and Mouth Disease (FMD) is a strategic infectious animal disease that is exotic to Indonesia. Indonesia succeeded in eradicating the disease, and was declared free in 1986, followed by recognition as FMD free internationally by OIE in 1990. Indonesia's FMD free status has been maintained up to present.

Although Indonesia is FMD free, the threat of FMD introduction to Indonesia remains high, given that the disease is still endemic in some of our neighboring countries. To prevent the entry of FMD, requires strategic technical measures, so that animal resources in Indonesia remain safe and protected. The Government of Indonesia has allocated resources to prevent the entry of FMD into the country through emergency preparedness, surveillance, and strengthening the capacity of officers and laboratories. Through this Cost Benefit Analysis it is hoped that feedbacks regarding the importance of FMD prevention activities and recommendations for improvements can be incorporated in the next FMD prevention program.

Gratitude and appreciation are conveyed to the writers who have worked hard in preparing this important document. Our gratitude is also expressed to the OIE Sub-Regional Representation for South East Asia (OIE SRR SEA) which has facilitated the preparation of this report.

I do hope this report on Cost Benefit Analysis for Maintaining FMD Freedom Status in Indonesia can provide benefits for animal health in Indonesia.

Jakarta, November 2017

Director General of Livestock and Animal Health Services

Dr. I Ketut Diarmita, MP

List of Abbreviation

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
AI	Avian influenza
APEDA	Agricultural and Processed Food Products Export Development Authority
BKPM	Indonesian Investment Coordinating Board
BNPB	National Disaster Management Agency
B/C ratio	Benefit Cost ratio
BPBD	Regional Disaster Management Agency
BPS	Indonesian Central Bureau of Statistics
BVet	Veterinary Laboratory
CBA	Cost Benefit Analysis
CGE	Computable General Equilibrium
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DIVA	Differentiating Infected from Vaccinated Animals
ELISA	Enzyme Linked Immunosorbent Assay
EU	European Union
FAO	Food and Agriculture Organization
FMD	Foot and mouth disease
GDP	Gross Domestic Product
HPAI	Highly pathogenic avian influenza
ICARD	Indonesian Center for Animal Research and Development
ICS	Incident Command System
IEC	Information, Education and Communication
IRR	Internal Rate of Return
Kiatvetindo	Indonesian Veterinary Emergency Preparedness
NPV	Net Present Value
NSP	Non Structural Protein
OAG	Office of the Auditor General New Zealand
OIE	Office International des Epizooties
OIE SRR SEA	OIE Sub-Regional Representation for South East Asia
PCP-FMD	Progressive Control Pathway for FMD
PO	Ongole cattle descendant
PPR	Peste des petits ruminants
Pusvetma	Indonesian Center for Veterinary Biologics
QA	Quality Assurance
RT PCR	Real Time Polymerase Chain Reaction
SAT	South African Territories
SIKHNAS	National Animal Health Information System
SIWAB	Sapi Indukan Wajib Bunting
SMS	Short Message Service
SPS	Sanitary and Phytosanitary
URC	Rapid Response Unit
USDA	United States Department of Agriculture
WTO	World Trade Organization

Glossary

Animal products	Meat products and other animal products of animal origin (such as eggs, milk) for human consumption or for use in animal feed.
Animal traceability	Ability to search for a cattle or a group of cattle during their life stage.
B/C ratio	An indicator, used in cost-benefit analysis that attempts to summarize the overall value for money of a project or proposal.
Compensation	A sum of money paid by the government to livestock owners as compensation for livestock or farm that must be destroyed for the purpose of eradication or prevention of an outbreak, and dead livestock due to disease outbreak.
Disinfection	Cleaning and application of procedures to eliminate disease agents or parasitic agents of diseases in the sheds, vehicles or other objects contaminated directly or indirectly.
Disposal	Destruction of animal carcasses, animal products, materials and remains by burying, burning or other means to prevent the transmission of a disease.
Endemic	A situation where a disease that infect animals (or human) is already happened in a country
Index case	The first case or case of origin of the disease diagnosed at an epidemic event.
Internal Rate of Return	The "annualized effective compounded return rate" or rate of return that sets the net present value of all cash flows (both positive and negative) from the investment equal to zero.
Investigation	An investigation involving a disease's diagnosis, pathology and epidemiology.
iSIKHNAS	Integrated national animal health information system based on disease syndrome report submitted by villagers through SMS.
Kiatvetindo	A technical response plan illustrating the Indonesian government's approach to an emergency incident of animal disease outbreak.
Morbidity rate	Levels indicating the extent of the disease or the frequency of the disease within a predefined animal population. Morbidity can be expressed either as a prevalence or occurrence.
Mortality rate	Levels that indicate disease fatalities characterized by the number of deaths in a predefined animal population.
Movement restriction	Restrictions imposed on the movement of animals and animal products and other disease-carrying media to prevent the spread of disease.
Net Present Value	A measurement of profit calculated by subtracting the present values (PV) of cash outflows (including initial cost) from the present values of cash inflows over a period of time.
Reproductive number	The number of secondary infections expected to emerge from a single individual during the period of transmission in a sensitive population.
Ripple effects	An effect that continue and spread as the result of an incident or action.
Serotype	A subgroup of microorganisms identified by the antigen it carries (determined by a serological test).
SIWAB	A national livestock breeding program to increase cattle population through artificial insemination.
Spillover effects	Externality of an economic activity or process that affect those who are not directly involved.
Stamping out	A strategy for the eradication of diseases by quarantine and rapid slaughter of all susceptible animals either infected or has contact or exposed to infected animals or all animals in the infected area.

Susceptible animal	Animals that can be infected by a particular pathogen.
Surveillance	A program designed systematically to determine the existence of a disease, extension of disease, or absence of disease, or infection or contamination with the originated organism. This includes the examination of livestock for clinical symptoms, antibodies or originated organisms.
Vaccine	Modified disease-carrying strains, when inoculated into the animal or human body can stimulate the immune response and provide protection against the disease.
Vaccination	Individual inoculation with the vaccine to obtain active immunity.
Veterinary Authority	The authority of government officials who have the responsibility and competence to ensure or supervise the implementation of animal health and welfare, animal health certificates, and the standards and recommendations set forth in the OIE Code in the whole of their territory.
Zoning	The process to establish and maintain disease-free areas or infected areas under the OIE guidelines, based on geopolitical limits, animal movement and surveillance, in order to facilitate the trade and/or disease control.
Zoonosis	An animal disease that can naturally be transmitted to human.

Table of Contents

List of Tables

List of Figures

List of Appendices

Summary

Indonesia needs to increase the productivity of native cattle in both breeding and fattening to become beef self-sufficient by 2025. To overcome the shortage of local livestock and reduce imports of cattle for breeding, the Government of Indonesia is implementing an artificial insemination program to increase breeding productivity – SIWAB (Sapi Indukan Wajib Bunting). The need of increasing breeding productivity through SIWAB could be hampered by the presence of Foot and Mouth Disease (FMD).

FMD is the most of important exotic livestock disease internationally and would be a major obstacle for the Indonesian cattle industry to achieve its self-sufficiency target. The decision to import deboned beef from a country where FMD is present increases the risk of exposing Indonesia's cattle herd to the disease. Although the risk of FMD virus entering Indonesia via deboned meat may be justified on social and economic criteria, Indonesia should be vigilant in protecting its live cattle and managing beef import policies.

The purpose of this study is to assess the potential economic impact from an outbreak of FMD, to estimate the benefit-cost ratio of prevention measures to protect the country against FMD, and to estimate the required annual FMD preparedness cost to maintain its FMD freedom.

Three scenarios were developed to estimate the economic impact due to an FMD outbreak in Indonesia, using the hypothetical example of Probolinggo district in East Java province being infected, as follows:

- Scenario 1 ('best case' scenario), a local scenario which requires 2 weeks for detection, investigation and confirmation, so the outbreak is limited to the villages in one sub district, and requires 6 months to control the outbreak.
- Scenario 2 ('most likely' scenario), a district scenario which requires 4 weeks for detection, investigation and confirmation, so the outbreak includes the subdistricts in three neighboring districts, and requires 12 months to control the outbreak.
- Scenario 3 ('worst case' scenario), a province scenario which requires 8 weeks for detection, investigation and confirmation, so the outbreak spreads to two neighboring provinces in the Java island, and requires 24 months to control the outbreak.

The scenarios were developed with the assumptions that the FMD incursion occurs in beef cattle only, not dairy, and not involving any other species. By excluding these, the assumption can be made that the potential economic loss would likely be far greater than has been estimated using the developed scenarios.

The result of the Cost Benefit Analysis (CBA) shows that if an FMD incursion occurs in Indonesia every effort should be made to restrict the outbreak to a scenario 1 ('best-case' scenario) and so have the maximum Benefit Cost Ratio of the cost of control measures against the economic impact. Although scenario 2 ('most likely' scenario) is more likely to be occur in a country such as Indonesia, the result of the CBA shows that the benefits are only slightly larger than the costs. Scenario 3 (the 'worst-case' scenario) should be avoided as much as possible since the costs outweigh the benefits and potential losses may be unrecovered, even over an extended period (see Table).

The potential losses from FMD at national level can be assessed from the direct costs that can be saved by the farmers when their livestock are not affected by FMD (vaccination, increased biosecurity, movement control, etc.), and indirect costs due to trade restriction, and the costs incurred due to the impact on the non-agricultural sector. The total estimated losses in a year for Indonesia are estimated to be Rp 9.9 trillion (US$ 761.3 million), which includes the loss in cattle production,

impacts on trade and on industry including declining domestic cattle price and beef sales as a consequence of the ripple effect, and decrease in tourism expenditures as the spill-over effect.

Cost-Benefit Analysis of FMD Outbreak Control (5 years; discount rate = 7.4%)

Scenario	Time of Detection	Duration of outbreak control	No. of cattle affected (head)	Control measures	B/C ratio	IRR
Best case	2 weeks	6 months	1,006	Culling 100% and vaccination for all cattle in the affected district	4.27	46.2%
Most likely	4 weeks	12 months	55,438	Culling 20% and vaccination all cattle in the affected districts and neighboring districts	1.43	14.8%
Worst case	8 weeks	24 months or more	201,951	Vaccination all cattle in the whole island of Java for 3 years	0.32	-18.1%

Indonesia needs to develop effective emergency preparedness and response systems to maintain its 25 years of FMD-freedom. It is estimated that the annual FMD preparedness costs required to protect the Indonesian livestock assets and economy are Rp 7.7 billion (US$ 594,231). The total preparedness cost can be justified by the total economic losses of the most likely hypothetical scenario (Rp 414.5 billion or US$ 31.9 million) if an FMD outbreak were to occur considering an outbreak in only one species in one district in East Java province. This preparedness cost can be further justified in comparison with the overall potential economic losses caused by FMD at the national level of Rp 9.9 trillion (US$ 761.3 million).

CHAPTER I

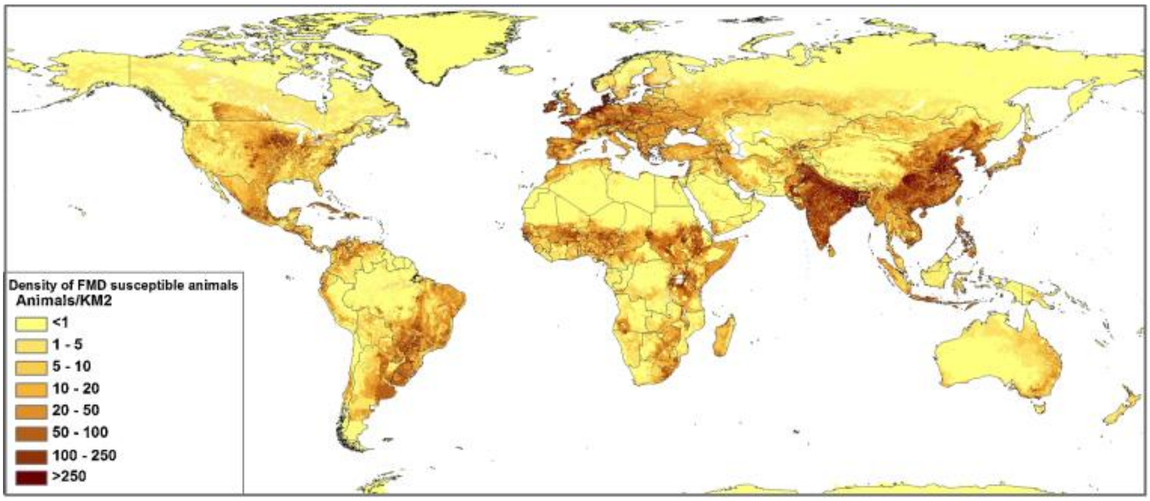
BACKGROUND

Indonesia is a country free from Foot and Mouth Disease (FMD), a very contagious viral disease that can infect all species of cloven-hoofed animals, including cattle, sheep, goat, pig, deer, buffalo and camel. This disease is rarely fatal to adult animals, but can cause high mortality in young stock. Clinical symptoms include fever and lesions on the tongue and lips, inside the mouth, on nipples and between the nails (Buetre et al., 2013).

Some important points regarding FMD:

- FMD does not affect humans, and there is no risk for food safety related to the consumptions of products originating from animals infected with FMD.
- The organism that causes FMD is a virus that belongs to the family *Picornaviridae*. There are 7 (seven) strains that has been identified (A, C, O, Asia 1, SAT1, SAT2 and SAT3).
- The global susceptible cattle density per km^2 is presented in Figure 1.

Figure 1: The number of cattle susceptible to FMD per km^2



Source: Wint and Robinson, 2007; Di Nardo et al., 2011.

Indonesia is an archipelago that consists of 34 provinces with total area of 1.9 million km^2, with a population of 257.9 million in 2016. Indonesian Gross Domestic Product (GDP) in 2016 was ranked 16th in the world at US$ 932.2 billion (Rp 12,240 trillion) (World Bank, 2017). GDP per capita is estimated at US$ 3,605 (Rp 48 million) (Indonesian Central Bureau of Statictics, 2017). The agricultural sector contribution to national GDP is 10.2% with a livestock subsector contribution to national GDP of 1.6% that is 15.8% to agricultural GDP (Livestock and Animal Health Statistics, 2016).

The livestock population in Indonesia in 2016 is poultry (1.6 billion), goats (19.6 million), sheep (18 million), beef cattle (16 million), dairy cattle (534,000) and pigs (8.1 million); the livestock sectors with the highest economic significance are poultry and cattle (Livestock and Animal Health Statistics, 2016). The current livestock business in Indonesia especially for large ruminants is dominated by smallholder (98%) with low production capacity. The low production capacity is aggravated by traditional animal husbandry practices.

The possibility of FMD entry into FMD-free countries, including Indonesia, is quite high considering that more than a hundred countries in the world are still endemically infected with FMD (Jamal and Belsham, 2013). Countries infected with FMD provide an ongoing threat to FMD-free countries (OIE and FAO, 2012). If an FMD outbreak occurs in Indonesia, which has been an FMD-free country since 1986 (officially recognised by OIE in 1990), and infected the ruminant population, particularly cattle, then it would present grave difficulties for Indonesia to halt the epidemic and not result in an endemic disease situation, due to the low performance of its veterinary services and as preparedness efforts are not yet optimal.

1.1. The FMD Global Situation

FMD is widely believed to be the most economically devastating livestock diseases in the world (USDA, 2007). FMD is endemic in many low-income countries, including in most parts of Asia, Africa, and the Middle East, and a few countries in South America (Fukaso, 2012).

The global FMD situation is dynamic and complex and affected by viral evolution, host immunity and changing ecosystem and trading patterns. Despite the opportunities for the spread of FMD virus into new regions, viruses tend to recur in the same parts of the world, presumably reflecting some degree of either ecological isolation or adaptation. On this basis, the global pool of FMD viruses can be subdivided into seven ‘regional pools’ in which genetically and antigenically distinctive virus strains tend to occur within a defined region (OIE/FAO FMD Reference Laboratory Network, 2015).

FMD is very contagious and the risk of FMD for countries free from the disease has increased due to the increased global movement and trade of livestock and livestock products, as shown by the incidence of epidemics in Taiwan (1997, 2009 to 2013 consecutively), UK (2001, 2007), Japan (2010) and the Republic of Korea (2010, 2017). A country that fails to control FMD may negatively impact on its neighbouring countries and trading partners, which is why control of FMD is considered to be a global public good, where there is a tendency towards universality in the sense that it benefits all countries, population groups and generations (OID and FAO, 2012).

The total annual impact of FMD in terms of visible production losses and vaccination in endemic regions alone amounts to between US$ 6.5 billion (Rp 86.7 trillion) and US$ 21 billion (Rp 279.6 trillion). This excludes the impact of losing trade opportunities or restriction to the development of the livestock sector, which can be huge. In addition, outbreaks in FMD-free countries and zones cause losses of more than US$ 1.5 billion (Rp 20 trillion) per year (Knight-Jones and Rushton, 2013). One of the most notorious epidemics occurred in the UK in 2001 with estimated losses of more than US$ 9 billion (Rp 119.9 trillion) (Knight-Jones, 2014).

1.2. The History of FMD in Indonesia

FMD was endemic in parts of Indonesia since it was reported for the first time in1887. There were several years with a high incidence of FMD such as in 1973 when 19,683 cases were reported. The disease spread to Sumatera, South Sulawesi, and Kalimantan through illegal cattle and buffalo movements from East Java (Bain, 1982).

An FMD outbreak that occurred in Jembrana District, Bali in 1973 was controlled by slaughtering of around 250 cattle and buffaloes, however a new outbreak occurred in 1974 involving more than 6,000 cases. A project for FMD eradication, supported by the Australian Government, with the vaccination of large ruminants was started in Bali and then moved through eastern Java. The project proved to be extremely succesfull with no cases seen in Bali after 1974 (Windsor, 2015).

The national FMD eradication program was started by taking the Bali experience in eliminating the disease by vaccinating of 80% of cattle and buffalo populations but not goats and sheep, although pigs were sometimes vaccinated when in close contact with an outbreak in the latter stages of the program outside Bali. The national eradication approach was only to vaccinate cattle and buffalo with one round in Bali, Sumatera, and South Sulawesi from 1977-1978 and three rounds in Java. The stamping out policy was not carried out due to economic, cultural, and political reasons. Slaughter-out was considered not feasible due to the role of livestock as major economic assets of smallholders (Windsor, 2015).

FMD eradication was conducted using international vaccine up to 1981, when domestic production was initiated. With assistance from the Australian Government, a local vaccine production facility was built in the Center for Veterinary Biologics (Pusvetma). The FMD-free declaration was delayed until 1983 to ensure no further introduction of disease, particularly from Malaysia and the Philippines that were infected at that time (Bain, 1982).

The declaration was then postponed again with the emergence of the last FMD outbreak in Blora district, Central Java in 1983. The outbreak spread to East Java and within 2 weeks affected all of Java through livestock movement and meat trade (Directorate General of Livestock Services, 2002). After reconducting the vaccination program for three consecutive years (1983-1985) in the whole of Java, no more FMD cases were reported from within the territory of Indonesia.

FMD eradication in Indonesia was successful as there are several advantages, such as the natural boundaries between islands, not all islands being infected with FMD, and only one FMD virus serotype was involved. Delay in implementing eradication measures can increase the risk of new serotypes entering the country, thus greatly increasing the eradication costs. Furthermore, the need for increasing productivity through genetic improvement in the future would be compromised in the presence of FMD (Hutabarat and Holden, 1991).

1.3. Cattle Production in Indonesia

Cattle are the second most important livestock sector in Indonesia after poultry. Indonesia's per capita consumption of beef, currently just less than 3 kg annually, is expected to hit double digits growth within the next two decades (Ministry of Trade). The Government of Indonesia is currently aiming for self-sufficiency in beef to maintain domestic price stability, make beef more affordable to consumers, and support the livelihoods of local farmers. The target for beef self-sufficiency is to be achieved by 2025, however it is assumed that the country will still need to import around 10% of the country's total demand.

Table 1: Cattle industry in Indonesia (2016)

	2014	2015	2016
Total beef cattle population (head)	14,726,875	15,419,718	16,092,561
Total beef production (tons)	497,670	506,661	524,109
Live cattle import (head)	729,400	604,120	618,323
Value of cattle import (US$)	682,097,525	545,576,172	601,463233
Beef import (kg)	76,887,337	50,309,023	116,761,381
Value of beef import (US$)	358,101,409	237,157,839	493,726,376
Beef export (kg)	2,069	6,750	14,841
Value of beef export (US$)	4,253	12,700	23,103

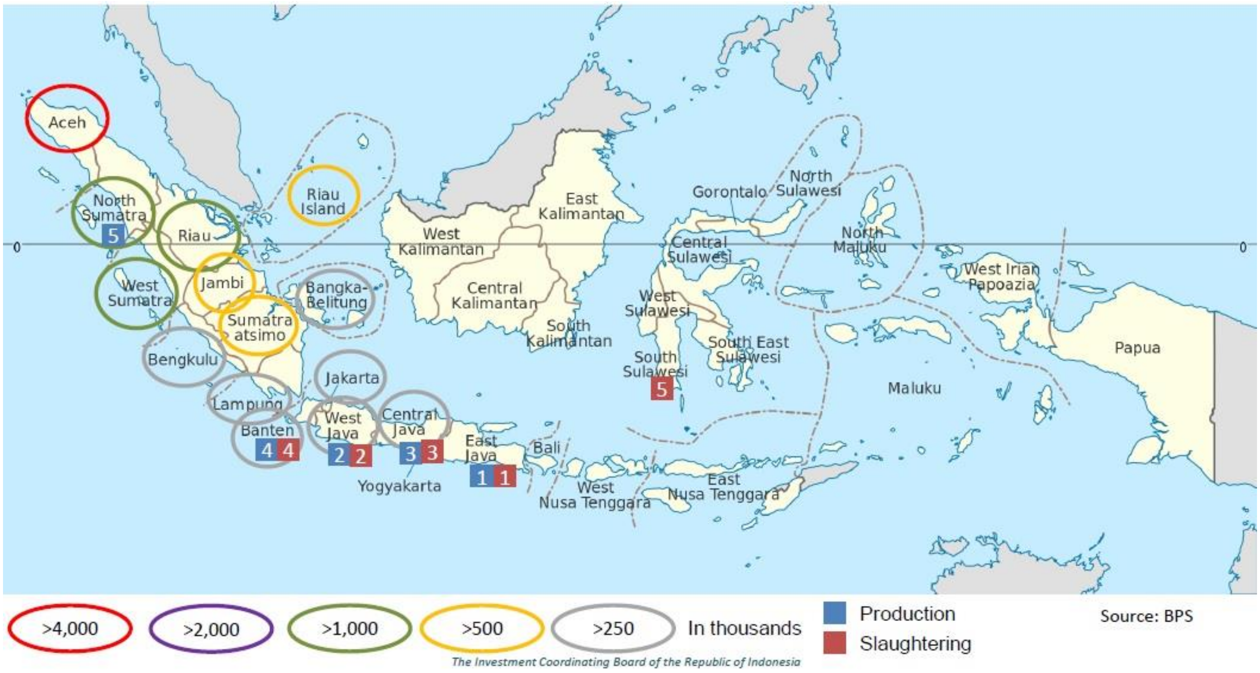
Source: Livestock and Animal Health Statistics, 2017

Indonesia is still heavily reliant on imports of live cattle and beef. The key challenge to increasing local production is scaling up production by smallholder farmers, which have lower productivity and lower quality beef in comparison to imported alternatives. The other obstacle to Indonesia's self-sufficiency in beef is insufficient government support in strengthening the know-how of local breeders. The Indonesian government therefore has to focus on the supply side to counter spiking prices through efforts such as expanding cattle farms in areas including South Sumatra, West Nusa Tenggara, and Sulawesi. The performance of cattle industry in Indonesia is presented in Table 1.

The capability of East Nusa Tenggara province, which has Indonesia's fourth largest cattle population, to take a bigger role in fulfilling the country's beef demand is a potential to be explored. However, the fact remains that the vast majority of Indonesia's beef is consumed in the population centers of the western islands of Java and Sumatra, which require a larger supply of meat than is currently provided by the many cattle farms in East Java province. The largest livestock labour force is in East Java province which occupies 42% of the total employment in livestock sector (Livestock and Animal Health Statistics, 2016). While

Sumatra is home to most of the cattle population, Java has the greatest concentration of the slaughter houses and production sites - 22% in East Java and 11% in West Java. The cattle main population and production locations are shown in Figure 2.

Figure 2: Indonesia's cattle industry concentration



Source: Indonesia Investment Coordinating Board, 2015

It is estimated that Indonesia needs to produce 42 million cattle from its stock of 5.6 million female cattle to become beef self-sufficient by 2025. To overcome the shortage of local livestock and reduce imports of cattle for breeding, the government is implementing an artificial insemination program to increase breeding productivity – SIWAB (Sapi Indukan Wajib Bunting). The program aims to provide 2 to 3 million frozen semen straws a year for cattle breeding within a six year period. In addition, an estimated another three years is needed to make Indonesia self-sufficient in the downstream sector.

FMD is the most of important exotic livestock disease which might prevent the Indonesian cattle industry achieving its self-sufficiency target. The Animal Husbandry and Animal Health Law of 2014 widens the scope of countries from which Indonesia can source animal products, allowing imports from countries or zones free of FMD. The decision to import deboned beef from a country where FMD is present increases the risk of exposing Indonesia's cattle herd to the disease. Although the risk of FMD virus entering Indonesia via deboned meat may be justified on social and economic criteria, Indonesia should be vigilant to protect its live cattle and beef import policies.

1.4. Economic Loss Due to FMD

The international community is increasingly concerned about the global social and economic impacts of endemic and epidemic infectious animal diseases that have increased over time. Many infectious animal diseases, including FMD, are endemic in much of the developing world. Only since 2001 has the severity of outbreaks of FMD that occurred in Europe, Latin America, Africa, and Asia demonstrated that such events can have significant impacts on international meat markets (Agra CEAS Consulting, 2007).

A country's specific characteristics, such as its export or import dependency, cattle stock and management, disease control policy, demography and consumer reactions, and cattle values, make it difficult to extrapolate the FMD impact between different countries (Schoenbaum and Disney, 2003).

A country's specific characteristics, such as its export or import dependency, cattle stock and management, disease control policy, demography and consumer reactions, and cattle values, make it difficult to extrapolate the FMD impact between different countries (Schoenbaum and Disney, 2003).

The presence of FMD creates problems for all livestock owners in populations where the disease is present. This connection may be geographically or via market chains. Therefore, FMD creates so-called 'externalities' that is if an outbreak occurs because one farmer did not protect his livestock, then others may also suffer the consequences. Conversely when a livestock owner protects their animals from FMD infection they will generate a positive externality as they are less likely to become infected and transmit the infection to other farms (Knight-Jones and Rushton, 2013).

Considering the externalities of FMD, theres is a need for government investment as the actions of one farmer create costs/provide benefits for others. However, these externalities are not equally shared amongst different livestock sectors (Perry and Randolph, 2003) with production losses being particularly severe for commercial dairy farms. Even when individuals gain positive benefits from succesfull FMD control, there is less incentive to undertake such a program if there is a high risk of reinfection from those that do not attempt FMD control (Knight-Jones and Rushton, 2013). The economic losses of FMD in a number of countries are presented in Table 2.

Table 2: Economic loss of FMD in a number of countries

Country	Scope	Species	Total loss per year	Reference
India	National, per year	Cow, buffalo, sheep, goat and pig	12,000-14,000 crore (US$ 1.87-2.18 billion) (Rp 21.9-29.2 trillion)	Singh et al., 2012
Pakistan	Village, 6 months	Cow, buffalo	Rs. 27,448,000 (US$ 322,918) (Rp 4.3 billion)	Gorsi et al., 2011
Ethiopia	National, per year	Cow	1.354 billion birr (US$ 61 million) (Rp 812.9 billion)	Jemberu, 2016
Laos	National, per year	Cow and buffalo	US$ 13,512,291 (Rp 180 billion)	Nampanya, 2015
Laos	Village, per year	Cow and buffalo	US$ 30,881 (Rp 411.6 million)	Nampanya, 2015
Australia	National, 10 years	All susceptible livestock	>AUS$ 50 billion (>US$ 39.7 billion) (>Rp 529.8 trillion)	Buetre et al.,2013

CHAPTER II

METHOD OF ANALYSIS

2.1. Objective

The objective of this study is to estimate the economic and financial benefits to Indonesia from maintaining its FMD free status. Indonesia has been free from FMD for over 25 years – since 1990, and continues to protect this status from incursions of FMD from outside the country.

The outputs of this study are a Cost Benefit Analysis for an FMD incursion in Indonesia, using multiple scenarios, potential losses from FMD at national level, and the estimation of costs of FMD preparedness activities. It is expected that this information will be used to support advocacy with the decision makers of the Government of Indonesia and relevant stakeholders in the Indonesian livestock industry.

In South East Asia, Indonesia is one of few countries recognized as free of FMD, together with Brunei Darussalam, Singapore, and the Philippines. Other countries in South East Asia, as well as China and India, continue to be endemically infected with FMD which increases the risk of FMD to Indonesia.

2.2. Economic Impact of Animal Diseases

The impact of anmial disease is not equal across countries and livestock populations due to differences in the species and genetics of livestock, the management of the livestock, and the prevailing prices for livestock systems inputs and outputs (Rushton, 2009; Rushton and Knight-Jones). The impact of FMD is complex with direct and indirect impacts, as well as visible and invisible impacts. All these impacts are substantial, difficult to estimate and highly variable (Knight-Jones and Rushton, 2013).

The elements of FMD impact are as follows:

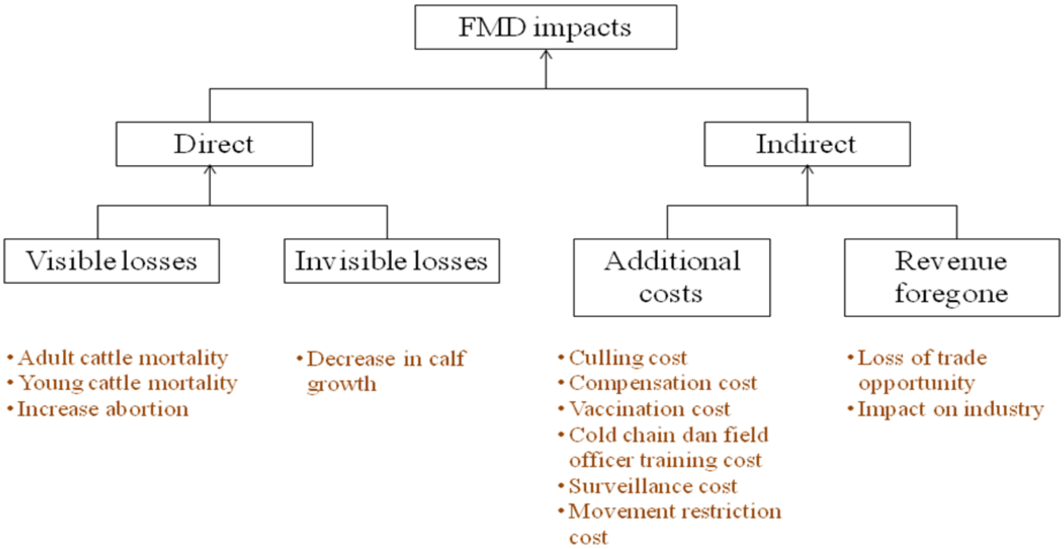
(1) Direct impacts
Direct impacts occur if the disease directly affects the economic value of the product's quantity and quality. Direct impacts can be in form of: (a) visible impacts, such as cattle mortality or decrease in cattle performance; and (b) invisible impacts where fertility is affected causing a herd's structure to change with import of additional animals required.

(2) Invisible impacts
Invisible impacts are caused by other factors related to the disease (other than direct impacts to production) that increase the cost of production or reduce the economic value of the product. Invisible impacts include: (a) cost for disease control and management; and (b) reduced income due to the disease, which includes: (i) technology application, especially in genetice improvement and a more intensive production system; and (ii) market opportunity, either in local, national and/or international level (Rushton and Knight-Jones, 2013).

Furthermore, invisible impacts can also be calculated against the primary sector, the processing sector, and also those related to non-agriculture sectors, such as tourism.

The following framework has been suggested by Rushton (2009) to assess disease impact as shown in Figure 3.

Figure 3: Direct and indirect impact of FMD[1]



2.3. Method

2.3.1. Literature search

Literature search includes journal articles and research report using online browsing by using key word "*FMD*" or "*foot and mouth disease*" and "*economic impact*" or "*financial impact*" or "*cost-benefit*".

2.3.2. Estimating Economic Impacts of FMD and Preparedness Costs for Indonesia

In the calculation model, it is assumed that the FMD outbreak only affects the beef cattle population. It does not calculate the effect if the outbreak also infects other susceptible species/production systems, such as dairy cattle, goat, sheep and pig. The outbreak cost will be greater if FMD also infects other species. The potential size of the outbreak will be higher if the detection speed and accuracy, investigation and response are delayed and response is less effective.

PART I: **Estimating the economic impacts of an FMD outbreak in Indonesia**

(1) Use existing data and information to describe the area impacted by an FMD outbreak including the affected production system and population structure;
(2) Conduct a literature search and discussion with experts to collect epidemiologic and economic data and other relevant information regarding the parameters used to calculate the losses or economic impact caused by FMD, both direct and indirect;
(3) Create a hypothetical FMD incursion with scenarios to estimate the potential economic impacts of FMD outbreak in Indonesia as follows:
    a. Scenario 1 (local/sub-district) – 'best case scenario'
    b. Scenario 2 (district) – 'most likely scenario'
    c. Scenario 3 (province) – 'worst case scenario'
(4) Use existing literature and discuss with experts to estimate the likely transmission rate for an FMD outbreak and create a simple model using the reproductive number (R_0) for each scenario (in MS Excel Spreadsheet).
(5) Identify the potential direct losses of an FMD outbreak and calculate the total direct losses during an FMD outbreak for each scenario in the affected area using a simple model (in MS Excel spreadsheet);

[1] Adapted from Rushton and Knight-Jones.

(6) Identify the potential indirect losses of an FMD outbreak and calculate the total indirect losses during an FMD outbreak for each scenario in the affected area using the models;

(7) Conduct sensitivity analysis on the model to assess the parameters have the greatest effect on the total losses/economic impacts during an FMD outbreak (in MS Excel spreadsheet).

(8) Calculate the economic benefits for an FMD free state per year by using a Cost Benefit Analysis (in MS Excel spreadsheet).

PART II: **Estimating potential losses from FMD at the national level**

(1) Use existing literatures as reference and in discussion with experts obtain data and information on financial impact on the beef cattle business in the infected areas and not-infected areas, and also on the export of animal and animal products as well as other commodities most likely to face trade restriction following an FMD outbreak.

(2) Estimate the financial costs following an FMD outbreak, plus the potential economic impact due to trade restriction and opportunity costs in the industrial, trade and tourism sectors.

(3) Sum up the financial cost from the impacts on cattle production, trade and industry, so that the overall impact is estimated at national level.

PART III: Estimating FMD Preparedness Costs for Indonesia

(1) Use existing literature and in discussion with experts obtain data and information on preparedness activities undertaken during peace time, and detail the costs required for each activity to maintain and improve optimum preparedness per year.

(2) Estimate the budget required for national FMD preparedness activities.

CHAPTER III

ECONOMIC IMPACT OF FMD OUTBREAK IN INDONESIA

A series of scenarios were developed to estimate the economic impact due to an FMD outbreak in Indonesia, including what is the most likely cause of the outbreak, what species are most likely to be infected, which area has the highest risk, and how great the outbreak magnitude might be. To understand the economic impact model presented in this paper, the following assumptions were made:

1. Although it is recognized that FMD virus can be carried into Indonesia through various ways, the outbreak is assumed to most likely be transmitted through the illegal meat trade.
2. Susceptible livestock species that can be infected by FMD virus are cattle, buffalo, goat, sheep, pig, and other livestock. From the history of FMD in Indonesia, it has predominantly infected beef cattle, so it is assumed that only beef cattle are affected and so the economic impact model is restricted to only beef cattle. Dairy cattle have been excluded from the model.
3. The outbreak scenario is assumed to be the area that has a high density of cattle population.
4. The epidemiology unit is a village where a group of cattle share a common environment and common management practices within the extensive Indonesian animal husbandry system that is excluding feedlots and other species.

3.1. FMD Outbreak Control Strategies

If an FMD outbreak occurs in a village or an area in Indonesia, the policy to tackle FMD outbreak is to control and eradicate the disease immediately and to prevent any damage to the farmers by applying several strategies in combination as follows:

1. *Culling,* including defining the infected area, immediate slaughtering of all infected and suspected animals as well as those exposed to infected animals, compensation for culled animals, sanitary disposal for culled carcasses and contaminated animal products, as well as cleaning and disinfection of all barns in order to eliminate source of infection.
2. *Quarantine and movement restriction of livestock and livestock products and other materials* in the area defined as the infected zone in order to prevent further disease transmission.
3. *Tracing and surveillance* to determine the source of disease, the level of disease transmission, and trace forward to new cases.
4. *Vaccination* is applied in some situations, if the disease cannot be controlled by only culling and the outbreak has become wide spread. Vaccination is used to protect animals against disease's clinical symptoms, to reduce the possibility of infection, and to decrease virus excretion by infected animals.
5. *Risk communication* through information, education, and communication (IEC) activities to prevent and minimize the impact of the FMD outbreak, both economically and financially, in particular to smallholders, livestock enterprises and related industries.

According to OIE when a FMD case occurs in an FMD free country or zone where vaccination is not practiced, the requirements to regain the free status are as stated in Box 1.

Given the situation that the majority of domestic beef cattle are in small scale farming, with limited logistic and financial resources as well as poor emergency response and preparedness, it is predicted that it would difficult for Indonesia to meet the requirements described by OIE. Therefore, the possible impact of FMD outbreak in Indonesia would be prolonged and the disease would tend to become endemic.

In the Indonesian context, culling during an outbreak is difficult to conduct using the conventional approach covering all infected animals and all animals having contact with the infected ones and/or within a certain radius of an infected farm or village. Culling is assumed to be more likely based on risk-based approach, where the farms/villages that have the highest expected number of secondary infections must be culled first. In applying this culling strategy, information is required such as the location of all farms in the area at risk, the time when the infected farms are detected, and estimation of distant-dependent probability of transmission (te Beest et al., 2011).

BOX 1: OIE Terrestrial Animal Health Code Chapter 8.8. (Article 8.8.7.):

The requirements to regain free status after FMD outbreak according to OIE are as follows:

1) 3 months after the disposal of the last animal killed where a stamping-out policy and serologic surveillance are applied; OR
2) 3 months after the disposal of the last animal killed or the slaughter of all vaccinated animals, where a stamping-out policy, emergency vaccination, and serologic surveillance are applied; OR
3) 6 months after the disposal of the last animal killed or the last vaccination where a stamping-out policy, emergency vaccination not followed by the slaughtering all vaccinated animals, and serologic surveillance are applied. However, this resuires a serological surveillance based on the detection of antibodies to nonstructural proteins of FMD virus to demonstrate no evidence of infection in the remaining vaccinated population.

If culling fails to be implemented to prevent disease transmission and eliminating infection in the early stages of the outbreak, then it is expected that immediate emergency vaccination will be conducted as suggested by the OIE. The decision to emergency vaccinate in an outbreak needs considerable preparation which is as important as the preparation for the vaccination itself. The selection of the most appropriate strain of FMD virus vaccines to use in the vaccination program is based on the matching of representative field isolates from the outbreak with the available vaccine strains. Difficulties may occur due to commercial contraints on the disclosure of the strain used for vaccine production and on the supply of reagents required for matching tests. There is limited *in-vivo* cross-protection information available, therefore it is essential to conduct validation of the vaccine matching method (Patton et al., 2005).

Once a suspected FMD outbreak occurs, the speed and accuracy in sample submissions to the regional or international FMD reference laboratories are very important. Recommendations regarding vaccine strain selection are obtained from such laboratories. It should be noted that infection or vaccination using one FMD virus serotype does not have the ability to cross-protect against other serotypes, and might fail to completely protect against other subtypes even of the same serotype (Jamal and Belsham, 2013).

3.2. FMD Outbreak Hypothetical Scenarios

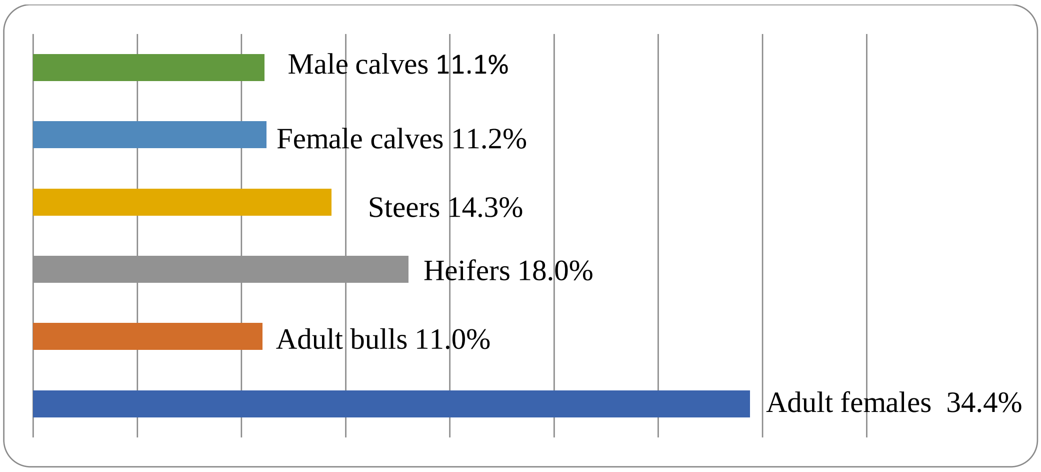
For the purpose of estimating the economic impact of FMD, this study uses hypothetical examples of a district based FMD outbreak in East Java province – Probolinggo district. East Java province is a cattle source area with a cattle population of 4,534,460 heads, which is the highest population in Indonesia (Livestock and Animal Health Statistics, 2016).

The East Java ruminant population for the last five years (2011-215) has been changing at an average rate of -0.72% for beef cattle, -2.52% for dairy cattle, -3.03% for buffalo, 2.61% for goat, and 7.28% for sheep (Livestock Animal Health Statistics, 2015). East Java province contributes about 28% of the national beef requirements (Sapi Bagus, 2017). A map of East Java province and the number of livestock susceptible to FMD in East Java province in 2016 is shown in Appendix 1.

The beef cattle population in Probolinggo district in 2016 is 262,408 heads, the fourth largest district ruminant population in East Java province. Probolinggo dictrict is one of the districts within East Java province with a potential for beef cattle development. The development pattern of beef cattle farming in this district is for more fattening and breeding. The greatest concentration of beef cattle in Probolinggo district is in the Krucil subdictrict (26,759 in 2013) (Probolinggo Central Bureau of Statistic, 2013). Krucil subdistrict comprises of 14 villages, which makes the average number of beef cattle per village to be 1,911 heads. The location of Probolinggo district and number of susceptible livestock to FMD in Probolinggo district is shown in Appendix 2.

Population structure in East Java province can be seen in Figure 4 below. The proportion of adult female cattle (cows) is 34.4% followed by heifers 18.0%, steers 14.3%, and adult male cattle (bulls) 11.0%. The proportion of female calves (11.2%) and male calves (11.1%) is almost the same.

Figure 4: Beef cattle population structure in East Java province



Source: ICARD, 2014

The FMD outbreak hypothetical scenarios that have been developed are shown in Table 3.

Table 3: FMD outbreak hypothetical scenarios

Scenario 1 – Local	• Requires 2 weeks for detection/confirmation/effective response. • FMD early detection with quick investigation result and diagnosis, so the outbreak is limited to one or more villages within one district. • Only a small number of smallholder farmers have infected cattle. • Requires 6 months to control the outbreak. • This is the '*best case scenario*', if detection, confirmation and response are conducted immediately after index case.
Scenario 2 – District	• Requires 4 weeks for detection/confirmation/effective response. • FMD detection, investigation and diagnosis are late, so the outbreak includes several subdistricts within one or more district(s). • The number of smallholder farmers that have infected cattle is relatively large. • Requires 12 months to control the outbreak. • This is the '*most likely scenario*', as delays in detection, investigation and diagnosis are very influential factor and this is likely to occur in a country free of FMD.
Scenario 3 – Province	• Possibly requires more than 8 weeks for detection/confirmation/effective response. • FMD detection, investigation and diagnosis are delayed, causing weaknessess and delays in early response and implementation of the control measures, so the outbreak spreads to several provinces. • The numbers of medium-scale and smallholder farmers that have infected cattle are very large. • Requires 24 months to control the outbreak or if fails it becomes endemic. • This is the '*worst case scenario*' and can be a regional or a national scenario if the delay and/or ineffective early response and control measures are prolonged.

3.3. FMD Transmission Rate Model

The rate of FMD transmission is defined by 'reproductive number' or R_0, which is the expected number of new infections arising from a single infection. R_0 is commonly used as a threshold parameter that predicts whether an infection will spread. The estimation of R_0 is of critical importance in understanding FMD outbreaks and the potential danger of transmission (Heffernan et al, 2005).

If $R_0<1$, each infected individual produces on average of less than one new infected individual, and therefore the infection will be cleared from the population. If $R_0>1$, the pathogen is able to invade the susceptible population. This threshold is the most important and useful aspect of the R_0 concept (Heffernan et al., 2005).

Argentina is amongst other countries with experience in controlling FMD outbreaks. A large FMD outbreak affected Argentina during 2001. The outbreak was controlled by mass vaccination and movement restrictions. The median R_0 decreased significantly from 2.4 (before the outbreak was officially recognized) to 1.2 during the mass vaccination campaign, and further decreased to <1.0 following the mass vaccination campaign. FMD outbreaks can only occur if $R_0>1$ (Perez et al., 2004).

Determining the magnitude of R_0 for FMD has also proved important as guidance for developing culling and vaccination policies, the two major control measures implemented for FMD. Ferguson et al. (2001) found that $R_0 = 4.5$ during the initial outbreak reduced approximately to 1.6 when control measures were implemented. The culling of all infected farms within 24 hours of case reporting can significantly slow the outbreak (without necessarily waiting for laboratory confirmation). However, in this study it was concluded that the improvement in culling times did not reduce R_0 to below one, therefore it was necessary to consider additional interventions other than culling, especially if the outbreak had spread to multiple areas.

In these scenarios, it is assumed that initially FMD transmission rate occurs with $R_0 = 2.0$. In scenario 1, the number of infected cattle is assumed to increase from initially one animal to 135 heads after 3 months, and reach the peak with 135 heads of infected cattle, then gradually decrease if the control measures can be undertaken within 6 months. The total number of infected cattle is estimated to be 1,006 heads (see Figure 5).

The FMD transmission rate model with $R_0 = 2$ for scenario 1 (best case scenario), scenario 2 (most likely scenario) and scenario 3 are presented in Figure 5, 6 and 7 respectively.

Figure 5: FMD transmission rate model with R_0=2 for scenario 1 (best case scenario)

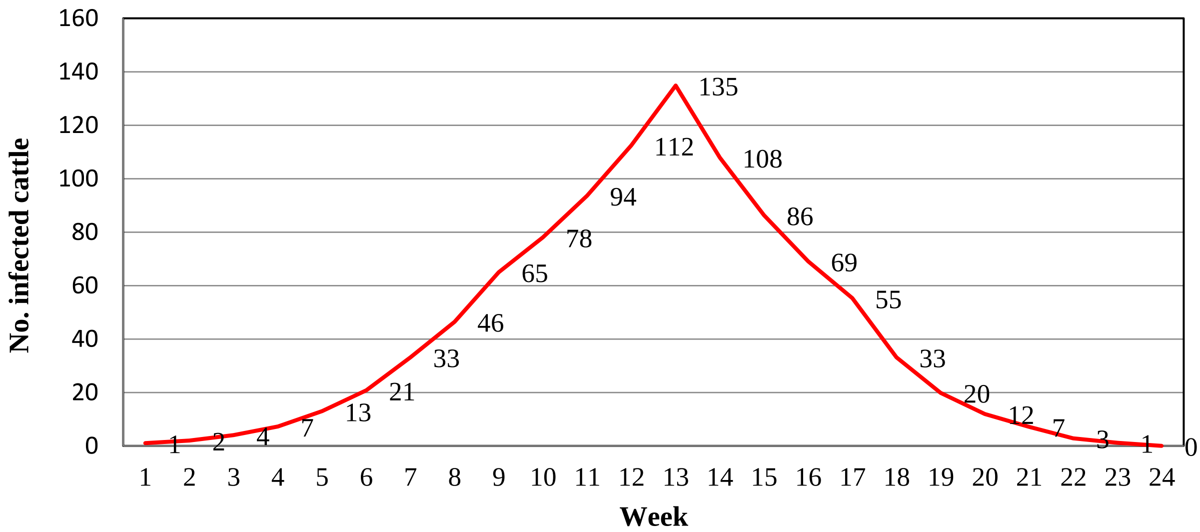


Figure 6: FMD transmission rate model with R_0=2 for scenario 2 (most likely scenario)

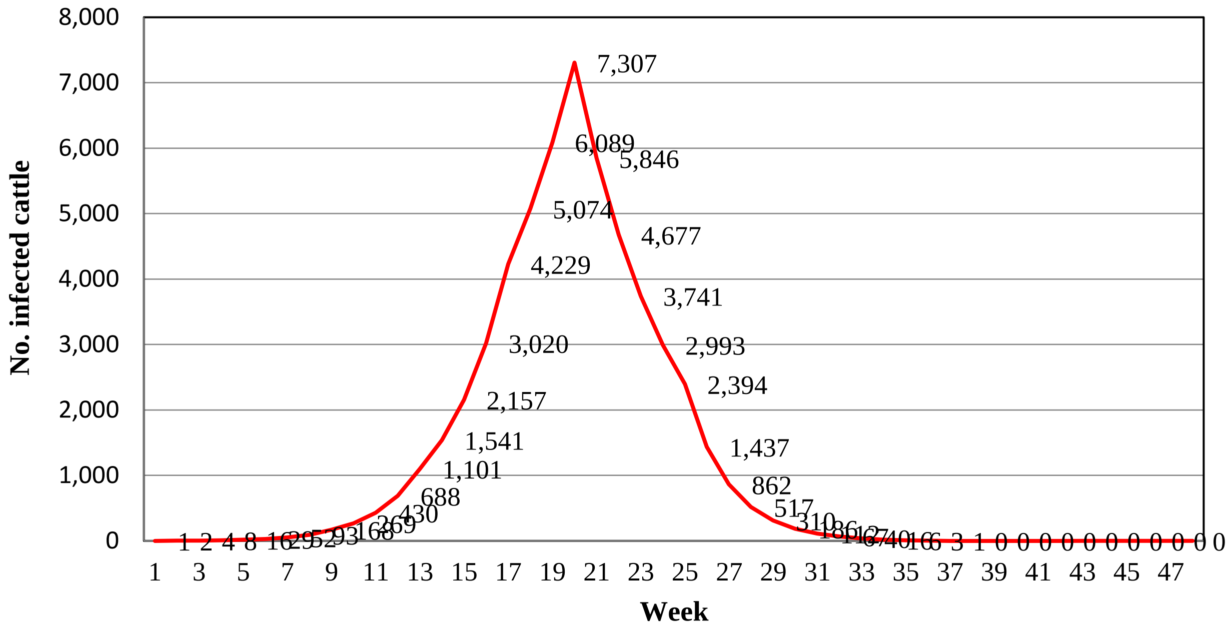


Figure 7: FMD transmission rate model with R_0=2 for scenario 3 (worst case scenario)

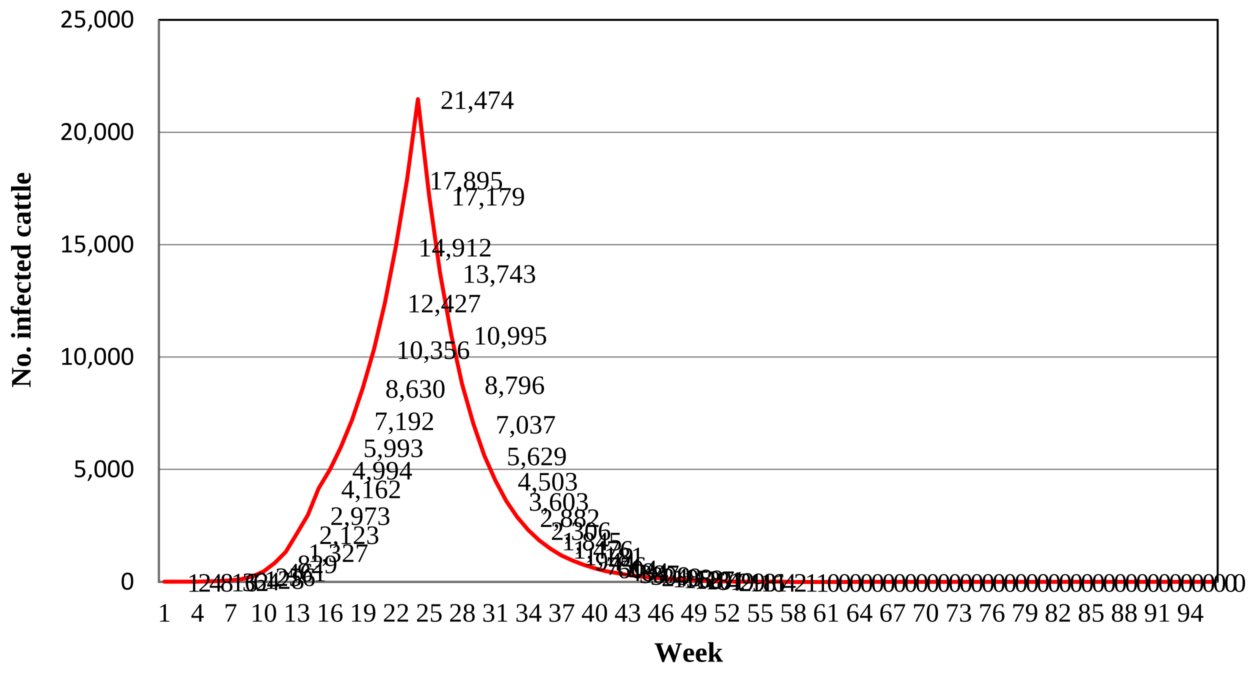


Table 4: Number of infected cattle per scenario ($R_0 = 2$)

Scenario	Time of Detection	Duration of outbreak control	Outbreak area	No. of cattle affected (head)
1	2 weeks	6 months	One or more villages within one district	1,006
2	4 weeks	12 months	Several subdistricts within one or more district(s)	55,438
3	8 weeks	24 months or more	Several provinces	201,951

In scenario 2, the peak of transmission rate occurs within 5 months with 7,307 infected cattle and after 12 months the total number of infected cattle is estimated to be 55,438. While in scenario 3, the peak is reached within 6 months with 21,474 infected cattle and the total number of infected cattle is estimated to be 201,951. The total number of infected cattle by FMD for each scenario is presented in Table 4.

3.4. Epidemiology and Economic Data

This paper estimates the annual impact of FMD in terms of production losses and the significant costs of the two main control measures for FMD which are culling and vaccination. The beef population structure in East Java province is presented in Appendix 1. Data on the impact of FMD on production is taken from studies in other countries. The components of FMD direct impacts used in the scenarios are set out in Table 5.

Table 5: Components of FMD direct impacts on cattle

Epidemiologic parameter	Value	Source
Mortality in adult cattle	2%	Wildpro (http://www.wildlifeinformation.org/)
Mortality in young cattle	5%	Wildpro (http://www.wildlifeinformation.org/)
Increase in abortion rate	10%	Doel, 2003; Singh et al., 2013
Decrease in calf growth rate	20%	Singh et al., 2013

To calculate the increase of abortion rate as FMD direct impact, it is necessary to get average pregnancy rate in East Java province. An overview information about of the pregnancy rate is $\leq$ 60% (Rosikh, 2015).

The costs due to the FMD are calculated based on the following assumptions:

1) The production system affected by FMD is beef cattle in Probolinggo district (see livestock data and in Appendix 2).
2) The unit cost for beef cattle production system affected by the FMD in point 1) is per head of animal.
3) The estimated number of cattle affected by the disease in the area of concern depends on the FMD transmission rate ($R_0 = 2$).
4) Total disease cost per year is calculated based on the cost of the cattle production system, length of time to control the outbreak as per scenario and estimated number of animal affected by the disease in the area of concern.

Table 6: Components of FMD indirect impacts on cattle

Technical and economic parameter	Value		Source
Adult male cattle selling price per head *	Rp	14,700,000	http://miefbird.blogspot.co.id/
Adult female cattle selling price per head **	Rp	11,025,000	http://miefbird.blogspot.co.id/
Young cattle selling price per head ***	Rp	7,000,000	http://miefbird.blogspot.co.id/
Calf selling price per head	Rp	5,000,000	Iskan, 2013
Culling rate (depend on scenarios)		20%-60%	Lee Szu-Yin, 2015

Technical and economic parameter	Value		Source
Culling & disposal cost per head****	Rp	500,000	Expert opinion and assumptions
Compensation per head (% market price)		70%	From adult cattle selling price
Vaccination rate		100%	Expert opinion and assumptions
Vaccine cost per head	Rp	40,000	Rushton and Knight-Jones, 2013
Vaccination operational cost per head	Rp	5,000	Expert opinion and assumptions
Required number of vaccinator *****	1000 heads/month		Expert opinion and assumptions
Vaccinator cost per person per month	Rp	8,000,000	Expert opinion and assumptions
Cold chain investment cost	Rp	250,000,000	Expert opinion and assumptions
Field officer training cost	Rp	75,000,000	Expert opinion and assumptions
Surveillance cost per investigation	Rp	15,000,000	Expert opinion and assumptions
Surveillance operational cost per investigation	Rp	30,000,000	Expert opinion and assumptions
Cost of sample delivery to reference laboratory	Rp	50,000,000	Expert opinion and assumptions
Border control cost per head	Rp	75,000	Expert opinion and assumptions
Disinfection cost per head	Rp	2,500	Expert opinion and assumptions
Outbreak management control cost per village	Rp	600,000	Expert opinion and assumptions
IEC cost per village	Rp	40,000	Expert opinion and assumptions

Remarks:

* Bull (PO local breed) selling price: Rp 14,700,000 - Rp 15,300,000.
** Cow (PO local breed) selling price: Rp 11,025,000-Rp 11,475,000.
*** Young cattle (PO local breed) selling price: Rp 6,500,000-Rp 7,500,000.
**** No government policy, but assumed 70% selling price compensation will be paid.
***** The number of vaccinator is calculated based on one person ability to vaccinate 1,000 cattle in 3 months.

To calculate the indirect impacts of FMD, it is necessary to obtain the cattle price per head according to sex and age group (adult, young, calf), as well as the costs required for each control measure. Considering the difficulties in obtaining the data since information was only collected from internet, therefore price is assumed only by average price per head and costs are estimations based on expert opinion. The components of FMD indirect impacts used in the scenarios are shown in Table 6.

The numbers of affected cattle per scenario in Table 4 were used to calculate the economic impact using parameters for direct impacts (Table 5) and indirect impacts (Table 6).

By the accumulation of all direct and indirect impacts, then the total economic losses of an FMD outbreak by scenarios can be obtained, as presented in Table 7. The detail of calculation of the economic impact model if an FMD outbreak occurs can be seen in Appendix 3. The MS Excel spreadsheet for the calculation of the economic impact model is presented in Appendix 4.

Table 7: Economic impacts if FMD outbreak occurs

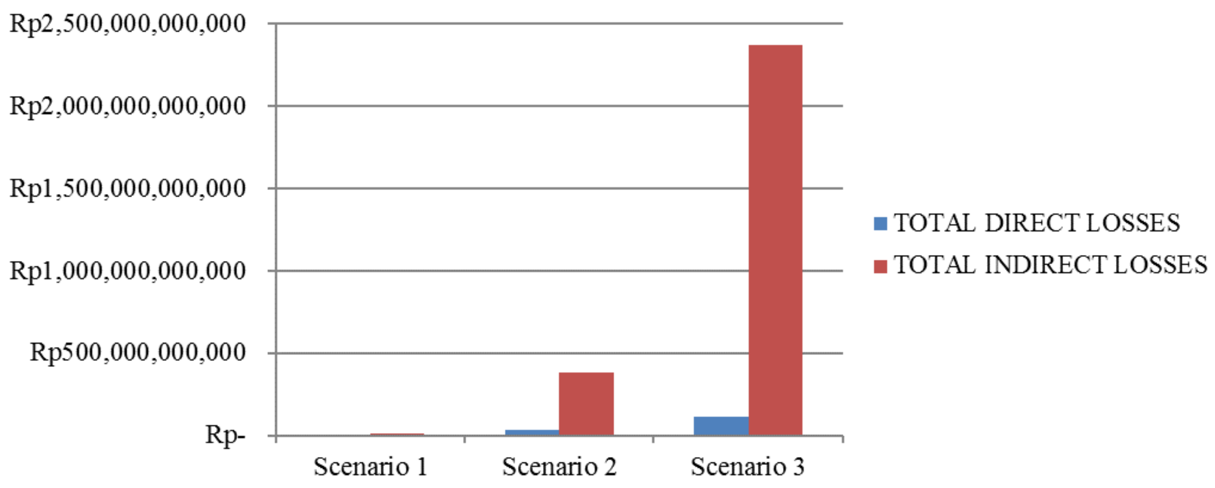
No.	DIRECT IMPACT	Total Loss (Rp)		
		Scenario 1	**Scenario 2**	**Scenario 3**
1.	Loss due to adult cattle deaths	108,841,152	6,003,357.696	21,489,482,592
2.	Loss due to young cattle deaths	113,728,300	6,272,918,400	22,830,560,550
3.	Loss due to abortion	103,819,200	5,726,361,600	20,841,343,200
4.	Loss due to decreased calf growth	224,338,000	12,373.824,000	45,035,073,000
	Total direct losses	**550,726,652**	**30,376,461,696**	**110,556,459,342**
No.	**INDIRECT IMPACT**	**Total Loss (Rp)**		
		Scenario 1	**Scenario 2**	**Scenario 3**
1	Culling cost	137,017,200	2,519,155,200	9,168,575,400
2.	Compensation cost	3,809,440,320	210,117,519,360	764,731,890,720
3.	Vaccination cost	1,908,146,900	99,305,717,332	1,117,168,647,404

No.	DIRECT IMPACT	Total Loss (Rp)		
		Scenario 1	Scenario 2	Scenario 3
4.	Cold chain & field officer training cost	325,000,000	550,000,000	850,000,000
5.	Surveillance cost	185,000,000	320,000,000	590,000,000
6.	Movement restriction cost	2,073,822,500	70,750,835,000	471,994,840,000
7.	Outbreak control management cost	195,000,000	517,000,000	9,319,800,000
8.	IEC cost	13,000,000	34,520,000	621,320,000
	Total indirect losses	**8,646,426,920 (US$ 665,100)**	**384,115,546,892 (US$ 29,547,350)**	**2,374,445,073,524 (US$ 182,649,621)**
	Total direct & indirect losses	**9,197,153,572 (US$ 707.473)**	**414,492,008,588 (US$ 31,884,001)**	**2,485,001,532,866 (US$ 191,153,964)**

The results presented in Table 7 shows that with the assumptions if an FMD outbreak affected beef cattle occurs in Probolinggo district, the total direct and indirect impacts from scenario 1 (best-case scenario) is Rp 9.2 billion (US$ 707.473), scenario 2 (most likely scenario) is Rp 414.5 billion (US$ 31.9 million), and scenario 3 (worst case scenario) is Rp 2.5 trillion (US$ 191.1 million).

The total indirect losses are much greater than the total direct losses for all scenarios. From the total direct and indirect losses, the proportion of indirect losses for all scenarios is more than 90% (scenario 1 = 93.6%, scenario 2 = 92% and scenario 3 = 95%. The total losses of scenario 3 is 270 times greater than scenario 1, and 6 times greater than scenario 2 (see Figure 8).

Figure 8: Total direct and indirect losses for scenario 1, 2 and 3



Knight-Jones and Rushton (2013) estimates that the annual impact of FMD in terms of visible production losses and vaccination in endemic regions alone amount to between US$ 6.5 billion (Rp 84 trillion) and US$ 21 billion (Rp 273 trillion). In addition, outbreaks in FMD free countries and zones cause losses of >US$ 1.5 billion (Rp 19.5 trillion) a year.

3.5. Sensitivity Analysis

Sensitivity analysis is used to assess whether the assumption or estimation used in a model is important or not. Furthermore, sensitivity analysis cans also assess the impact of an error or inaccuracy of the assumed values used in the model.

In the model outlined in 3.3. with the assumption of FMD outbreak attacks beef cattle population in Probolinggo district, there are six parameters of direct impact and indirect impact analyzed in order to determine whether or not the assumed values have impact to the final result, which is the total loss or economic impact due to the outbreak. Those values are estimated values which are less convincing or less certain.

For each of those values, extreme minimum and extreme maximum values are entered, while other inputs remain the same (see Table 8). The same process is performed to all identified parameters.

Table 8: Direct and indirect impact parameters being tested

No.	Parameter	Minimum Value	Most Likely	Maximum Value
1.	Mortality rate in adult cattle	0%	2%	10%
2.	Mortality rate in young cattle	2%	5%	20%
3.	Decreased calf growth	5%	20%	30%
4.	Adult male cattle selling price per head	Rp 2,000,000	Rp 14,700,000	Rp 18,000,000
5.	Young cattle selling price per head	Rp 5,000,000	Rp 7,000,000	Rp 9,000,000
6.	Vaccine cost per head	Rp 5,000	Rp 40,000	Rp 60,000

The calculation of the total loss during an outbreak with changes of parameters for mortality rate on adult cattle, mortality rate in young cattle, decreased calf growth rate, adult male selling price per head and young cattle selling price per head can be viewed as defined in Table 8. By using minimum value, most likely, and maximum value calculation for each tested parameter, the total losses for each parameter can be obtained from the result of sensitivity analysis as presented in Table 9.

Table 9: Total loss obtained from sensitivity analysis

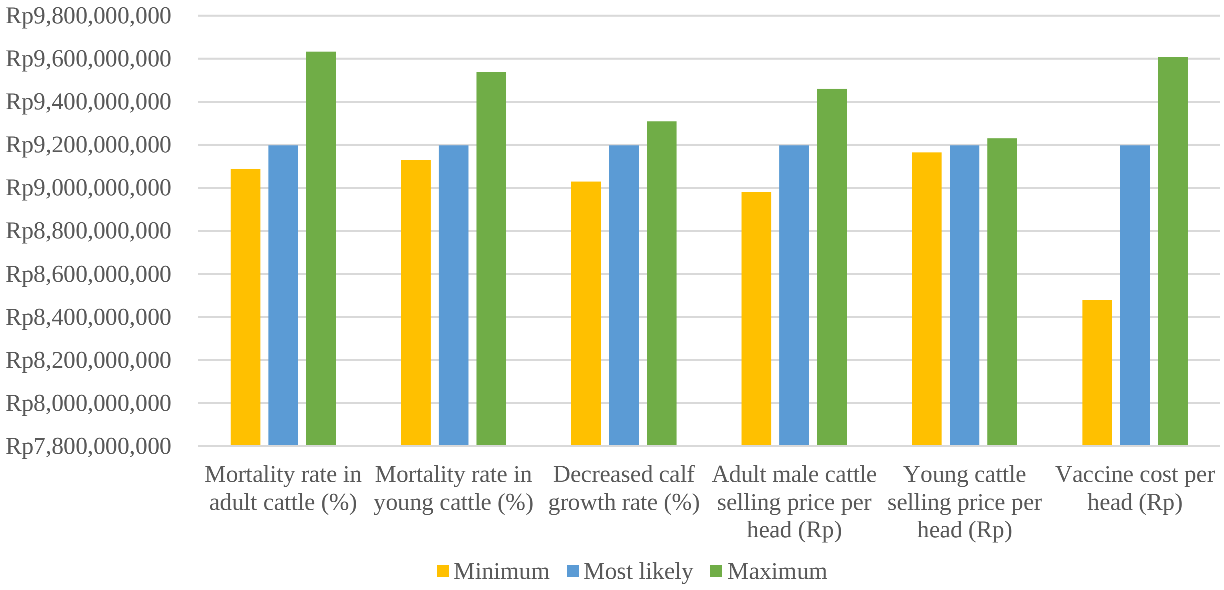
Tested Parameter	Total Loss (Rp)		
	Minimum	Most Likely	Maximum
Mortality rate in adult cattle	Rp 9,088,312,420	Rp 9,197,153,572	Rp 9,632,518,180
Mortality rate in young cattle	Rp 9,128,916,592	Rp 9,197,153,572	Rp 9,538,338,472
Decreased calf growth rate	Rp 9,028,900,072	Rp 9,197,153,572	Rp 9,309,322,572
Adult male cattle selling price per head	Rp 8,982,030,532	Rp 9,197,153,572	Rp 9,460,081,732
Young cattle selling price per head	Rp 9,164,659,772	Rp 9,197,153,572	Rp 9,229,647,372
Vaccine cost per head	Rp 8,479,033,771	Rp 9,197,153,572	Rp 9,607,507,744

From the interpretation of the sensitivity analysis result (see Figure 9), it can be concluded that one of the six parameters is most associated with the total loss or economic impact if an FMD outbreak occurs; the most sensitive parameter is the **vaccine cost per head**. The price of vaccine cost is the most sensitive parameter or factor against the final result, therefore it is apparent that the purchase of a low price FMD vaccine for emergency vaccination during an outbreak can significantly determine the amount of loss incurred.

This result also shows that mortality rate in adult cattle, mortality rate in young cattle, decreased calf growth, and young cattle selling price per head do not significantly affect the total loss or economic impact if an FMD outbreak occurs. The adult male cattle selling price per head slightly affects the total loss or economic impact.

This sensitivity analysis result supports the notion that the cost of FMD vaccine in poor countries is likely to be critical (Patton et al., 2009). Vaccine costs vary and are updated frequently, so establishing a specific cost per dose is impossible (Mortensen 2016). When the decision makers are considering vaccination strategy in an FMD outbreak in Indonesia, there are a number of challenges that can influence the vaccine cost such as the antigenic diversity of different serotypes and topotypes and differences in the cost of emergency vaccine (high potency) and the available commercial vaccines which are manufactured around the world.

Figure 9: Sensitivity analysis of the total economic loss if an FMD outbreak occurs



An estimated 2.6 billion doses of FMD vaccine are administered annually globally, with vaccine drug and delivery costs at between $0.4 to $3 per dose including delivery costs depending on the setting (Rushton and Knight-Jones). FAO stated that the cost of vaccine and vaccination represents over 90% of the total expense of FMD control so that it is essential to plan and evaluate vaccine and vaccination effectiveness to convince decision makers (Ferrari et al. 2016).

3.6. Cost-Benefit Analysis

Cost-benefit analysis for transboundary infectious animal disease is generally related to direct costs and benefits. The external costs or benefits or other indirect costs (farmers, consumers) are usually excluded from the calculation. The method used in this cost-benefit analysis is the value for money of outbreak control and the estimation of benefit obtained (Otte et al., 2004).

To perform cost-benefit analysis from the calculation model for economic impact of an FMD outbreak as described in Section 3.3., the first step is to make assumptions that will be used on the model, as per the following:

1. The calculated period is 5 years.
2. The discounted rate used is 7.4%.
3. The initial FMD outbreak is assumed as the first year.
4. It is assumed for scenario 1 and 2, the FMD outbreak occurs only in the 1st year and there is no further FMD case. For scenario 3, FMD cases still occur up to the 2nd year and then no further FMD cases.
5. Culling and compensation are only conducted on the 1st year for scenario 1 and 2, whereas in scenario 3 it is continued until the 2nd year.
6. Vaccination is conducted only in the 1st year for scenario 1 and 2, three consecutive years for scenario 3. In scenario 1 and 2, it is then ceased on the assumption that there is no more FMD case.
7. Surveillance is conducted every year, but will gradually reduce and only continue for free area surveillance. Surveillance in the 4th and 5th year consecutively is aimed at proof of freedom.
8. Movement restriction and IEC activities remain the same for the first 3 years then reduce after the 4th year.
9. Parameter changes on direct and indirect impact can be seen on Table 10 as describe below:
    a. The adult cattle mortality rate is 2% in the 1st year for all scenarios. It is assumed the adult cattle population is gradually increasing in the 2nd year by 0.5% until the 5th year.
    b. The young cattle mortality is 5% in the 1st year for all scenarios. For scenario 1, it is assumed the young cow population is increased in the 2nd year by 2% and gradually increased by 1% onwards.

For scenario 2 and 3, it is assumed the young cattle population is increased in the 2nd year by 1% and starting to increase in the 3rd year by 1% until the 5th year.

c. The number of calves born reduces by 10% due to abortion in the 1st year for all scenarios. For scenario 1 and 2, it is assumed that the calving rate is increased to 4% in the 2nd year and then gradually increased by 2% onwards. For scenario 3, it is assumed that the calving rate is increased to 2% in the 2nd year and then gradually increased by 2% onwards.

d. The calf growth decreases by 20% in the 1st year for all scenarios. For scenario 1 and 2, it is assumed that the calf growth increased by 5% in the 2nd year and starting to increase by 5% every year until the 5th year. For scenario 3, the calf growth is increased by 5% in the 2nd and 3rd year, and from the 4th to 5th year is increased by 5%.

Table 10: Parameter changes during FMD outbreak control from the 1st to 5th year

Parameter		Year				
	Scenario	1st	2nd	3rd	4th	5th
Adult cattle population growth	1	-2%	0.5%	1%	1.5%	2%
	2	-2%	0.5%	1%	1.5%	2%
	3	-2%	0.5%	1%	1.5%	2%
Young cattle population growth	1	-5%	2%	3%	4%	5%
	2	5%	1%	2%	3%	4%
	3	-5%	1%	2%	3%	4%
Calving rate improvement	1	-10%	4%	6%	8%	10%
	2	-10%	4%	6%	8%	10%
	3	-10%	2%	4%	6%	8%
Calf population growth	1	-20%	5%	10%	15%	20%
	2	-20%	5%	10%	15%	20%
	3	-20%	5%	5%	10%	15%

The Cost Benefit Analysis (CBA) calculation in this paper visualizes the whole FMD outbreak control measures for 5 years, with a hypothetical assumption that the outbreak affects only beef cattle in Probolinggo district using 3 different scenarios, which are scenario 1 (best-case scenario), scenario 2 (most likely scenario) and scenario 3 (worst case scenario).

The calculation of cost and benefit per year using outbreak control strategies including culling, vaccination, movement restriction, surveillance, outbreak control management and IEC can be seen in Table 11. In scenario 1, the outbreak control strategies are culling 100% and emergency vaccination of all cattle in the affected district. In scenario 2, the outbreak control strategies are culling 20% and vaccination of all cattle in several subdistricts in one or more district(s). While in scenario 3, there is no culling conducted but only vaccination of all cattle in the island of Java for 3 consecutive years.

The activities that continue to require annual investment in this calculation are surveillance, movement restriction and IEC. Compensation at 70% of market value is paid only when culling strategy is implemented. Outbreak control management is established during the duration of outbreak, which is only in the 1st year for scenario 1 and 2, but in the 1st and 2nd year for scenario 3.

The total costs for scenario 1 is only significant in the 1st year since the outbreak is contained within 6 months. By culling all of the affected cattle, it is assumed that no more cases occur from the 2nd year onward. In scenario 2, the outbreak control also shows the highest cost in the 1st year with only 20% culling compared to 100% culling in scenario 1. In scenario 3, the outbreak control cost is increased until the 3rd year since the vaccination strategy is targeting all cattle in the whole island of Java.

The total costs for scenario 1 in the 1st year are much less than the total costs in year 1 for scenario 2. The number of outbreak cases in scenario 2 is more than 50 times the number of cases in scenario 1, therefore the total costs for scenario 2 are almost 4 times higher than scenario 1. Whereas the number of outbreak cases in scenario 3 is more than 200 times the number of cases in scenario 1, which makes the total costs for scenario 3 more than 40 times higher than scenario 1.

The estimation of total discounted costs accumulated from culling, compensation, vaccination, cold chain and training field officers, surveillance, movement restriction, outbreak control management and IEC on average per year are Rp 10.3 billion (US$ 793.7 thousand) for scenario 1, Rp 47.8 billion (US$ 3.7 million) for scenario 2, and Rp 1.5 trillion (US$ 116.1 million) for scenario 3.

The estimation of total discounted benefits obtained from the adult cattle population increase, young cattle population increase, improved calving rate, and calf growth improvement on average per year are Rp 44.1 billion (US$ 3.4 million) for scenario 1, Rp 20.4 billion (US$ 1.6 million) for scenario 2, and Rp 487.5 billion (US$ 37.5 million) for scenario 3 (see CBA graphs for scenario 1, 2 and 3 in Figure 10, 11 and 12 respectively).

Figure 10: CBA graph for scenario 1 (best case scenario)

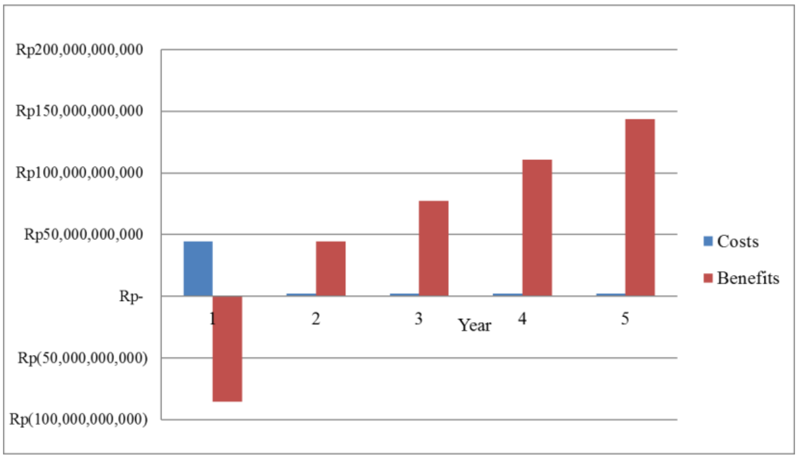


Figure 11: CBA graph for scenario 2 (most likely scenario)

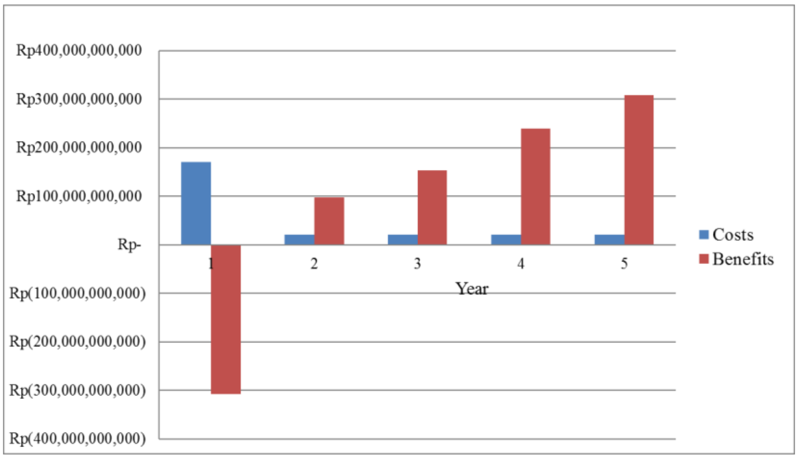
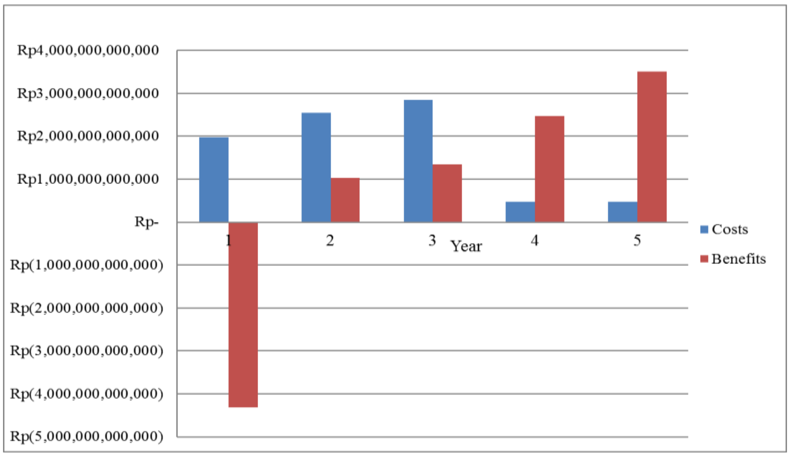


Figure 12: CBA graph for scenario 3 (worst case scenario)



With 7.4% discount rate, it is estimated that the net present value (NPV) for scenario 1 is Rp 168.8 billion (US$ 12.98 million), NPV for scenario 2 is Rp 102.1 billion (US$ 7.85 million), and only for scenario 3 yield is there a negative NPV of Rp 5.1 trillion (US$ 393.2 million).

The benefit cost ratio (B/C ratio) obtained by this calculation for the scenario 1 (best-case scenario) is 4.27 with internal rate of return (IRR) of 46.2%, which indicates for each rupiah invested for outbreak control measures four times of the benefit is expected. B/C ratio for scenario 2 (most likely scenario) is 1.43 with IRR of 14.8%, which indicates the benefits from the outbreak control measures still outweigh the costs. In contrast with the scenario 3 (worst-case scenario), the B/C ratio obtained is 0.32 with IRR of -18.1% meaning that the costs outweigh the benefits and therefore suggesting it should not be adopted (see Table 11).

Outbreak control measures using a vaccination approach is an ambitious long-term objective (McLeod, 2010). The costs and benefits calculation made with the worst case scenario assumption produce a B/C ratio less than 1, which indicates that the benefits from three years vaccination covering a much greater area most likely would not be seen within a 5 year period.

These results indicate that the time of detection of an FMD outbreak is critically important in making a rapid decision for cost effective control. With an 8 week delay the outbreak area has likely spread into several provinces, it is assumed that the outbreak tends to become endemic; it could yield a B/C ratio greater than 1 in a longer period of time, which is greater than 5 years.

The limitation of this CBA is that the outbreak only occurs in one species and one production system, it does not provide any calculation if the outbreak has spread further and infected other species. Other limitations such as the assumptions required, especially in predicting the benefit obtained is only from the direct impact of the outbreak control measures implemented. In addition, the numbers used are singular and cannot be tested against a confidence interval to include uncertainty.

Table 11: Cost-Benefit Analysis of FMD Outbreak Control (5 years)

Scenario	Time of Detection	Duration of outbreak control	Outbreak area	No. of catlle affected (head)	Control measures	NPV		B/C ratio	IRR
1	2 weeks	6 months	One or more villages within one district	1,006	Culling 100% and vaccination for all cattle in the affected district	Rp	168,828,283,427	4.27	46.2%
2	4 weeks	12 months	Several subdistricts within one or more district(s)	55,438	Culling 20% and vaccination all cattle in the affected districts and neighboring districts	Rp	102,114,946,172	1.43	14.8%
3	8 weeks	24 months or more	Several provinces	201,951	Vaccination all cattle in the whole island of Java for 3 consecutive years	Rp	-5,111,529,551,591	0.32	-18.1%

Cost Benefit Analysis in other countries

The impacts of infectious animal diseases are not always the same between countries and cattle populations due to the differences not only related to FMD status, incidents and attack risks, but also depend on (a) national population genetics, (b) current livestock management practice, (c) current price of cattle production inputs and outputs, and (d) the ability to supply cattle to export markets (Knight-Jones and Rushton, 2013).

In addition, interpreting and comparing the results of B/C ratios between countries as presented in Table 12, must be conducted carefully, due to the differences mentioned above. It must be noted that the calculation of a B/C ratio is affected by the availability of data on FMD and impact parameters that no longer exist in countries such as Indonesia, as it has already been free for a long time and does not have any experience in handling FMD outbreaks.

A number of Cost Benefit Analysis studies for FMD control and eradication conducted in several countries can be seen in Table 12.

Table 12: Cost benefit analysis study of FMD control and eradication

Country	FMD Endemic	Economic Return	C/B Ratio	Reference
Philippines	No	Commercial pig producer is estimated to obtain 8.4% benefit from eradication investment, compared to only 4% smallholder pig producers.	1.6-12.0 (depends on the export volume)	Randolp et al, 2002
Laos	Yes	Vaccination program cost runs quite effectively.	5.3	Nampanya et al., 2015
Thailand	Yes	If eradication cannot be obtained by 2020, the return remains positive without export, but on a lower level.	3.73-15.0 (depends on the export volume)	Perry et al., 1999
Kamboja	Yes	The successful FMD control program is expected to prevent estimated loss of US$ 135 million.	1.4	Young et al., 2014
U.S.A.	No	All strategies including vaccination are economically efficient and appropriate, whereas additional strategy such as culling, is not efficient and inappropriate (B/C 0.05 to 0.8).	5.0-10.1	Bates et al., 2003

CHAPTER IV

POTENTIAL LOSSES FROM FMD AT NATIONAL LEVEL

The benefit of an FMD-free state can be assessed from the direct costs that can be saved such as financial benefits borne by the farmers when their livestock are not affected by FMD, and indirect costs such as costs due to trade restriction, and costs incurred due to the impact on the non-agricultural sector (Dillon, 2006). Others state that generally in FMD-free countries, the economic costs are derived from active surveillance, increased biosecurity and awareness during peace time and eradication costs during an outbreak (Beyi, 2012).

4.1. Impacts on cattle production

The most direct economic impact of transboundary animal diseases such as FMD is the loss or reduced efficiency in production, which reduces farm income. If the farm economy is relatively diversified, and other income opportunities exist, the burden will be reduced. Conversely, if the local economy is heavily dependent on one or a few vulnerable commodities, the burden may be severe and local food security impaired (Otte et al., 2004).

Therefore, it is important to differentiate between farming systems and hence the cost of a particular disease can vary significantly depending on the production system. FMD, for instance, will cause higher production losses on dairy farms than in beef farms (Agra CEAS Consulting, 2007).

A study that assessed the economic effects of an FMD outbreak along the cattle market chain in several districts in Uganda showed that small and medium scale farmers incurred higher control costs, whereas large scale farmers experienced the highest milk losses. Total income earned by farmer per month from milk was reduced by 23%. In one district, salvaged bulls and cows were sold at 83% and 88% of market value, so the small and medium scale farmers subsequently suffer losses of US$ 196.1 (Rp 2.6 million) and US$ 1,552.9 (Rp 20.7 million) respectively (Baluka, 2016).

Another study aimed to estimate the production loss due to FMD in individual dairy and fattening cattle in Turkey. The average financial losses due to FMD for all breeds (Holstein, beef cattle and cross-breed) were estimated to be US$ 294 (Rp 3.9 million) per head for a milking cow, and US$ 152 (Rp 2 million) per head for a dairy cow and US$ 197 (Rp 2.6 million) per head for beef cattle. The financial losses varied aross different breeds, ages and sexes of the cattle (Şentűrk and Yalçin, 2008).

FMD incidence is highest in the regions where small scale farming is a commonplace. A study in Cambodia estimated that FMD outbreaks resulted in a reduction in household income of 4-12% (Shankar et al., 2012), while in several parts in Laos, it may account for 60% of the annual household income (Nampanya et al., 2013). A study in Laos and Cambodia estimated that affected cattle lose a quarter to three quarters of its original value (Rast et al., 2009). As cattle play an important role as assets that are cashed in at times of need, this has a severe impact on farmer livelihoods (Knight-Jones, 2014).

Financial Analysis

To estimate the financial impact of FMD outbreak in Indonesia, a simple analysis was conducted hypothetically in two villages in East Java Province that has Peranakan Ongole (PO) local breed fattening business for 4 months. It is assumed that FMD situation is already endemic and the outbreak occurs where one village does not conduct vaccination and the other does. The number of cattle in this analysis is assumed to be 260 heads in the unvaccinated village and 260 heads in the vaccinated one.

The assumptions made in the analysis are using the method conducted by Rast et al., 2010 in Laos and adapted to Indonesian conditions, as follows:

1) Average selling price per kg live weight is Rp 44,000/kg[2] with final average weight is 400 kg[3], therefore the average revenue obtained by the farmer from selling the cattle is Rp 17,600,000.
2) Average selling price of calf aged <12 months is Rp 5,000,000.
3) Costs for cattle treatment, including antibiotics and other treatments (such as antiseptic application on the FMD lesions to accelerate healing) and labor cost to conduct the treatment are estimated Rp 25,000 per head.
4) Cattle infected with FMD lose 30% of its body weight (Rast et al., 2009), therefore they lose 30% of the cattle value or the average selling price is reduced by Rp 5,280,000 per adult head.
5) Feed cost for a cattle beast before FMD outbreak is estimated to be Rp 9,100[4] per head per day to obtain a weight gain of 0.7 kg/day. Therefore, to regain the 30% or 120 kg weight lost requires 171 kg feed that costs Rp 1,560,000.
6) Vaccination cost is estimated Rp 45,000 per dose, consists of Rp 40,000 for vaccine and Rp 5,000 for injection operation and equipment.

The difference in mortality, morbidity, and vaccination rate in both villages are obtained from the research conducted by Rast et al., 2010, as illustrated in Table 13.

Table 13: Parameters in unvaccinated village and vaccinated village against FMD

Parameter	Unvaccinated village	Vaccinated village
Total population	260 heads	260 heads
Mortality rate	7.8%	0%
Morbidity rate	61%	1%
Vaccination rate	0%	100%

With the mortality as shown in Table 13, 20 cattle die (all are calves) in the unvaccinated village compared to no cattle dying in the vaccinated one. A calf selling price of Rp 5,000,000 indicates that the cost difference per head in the unvaccinated village is Rp 390,000 and Rp 0 in the vaccinated one (Table 14).

With the morbidity rate as shown in Table 13, based on the estimation of treatment cost Rp 25,000 per head and estimated 95% of the infected cattle were treated, then the cost difference per head is Rp 14,488 in unvaccinated village and Rp 238 in the vaccinated one.

[2] Local ready-to-slaugher beef cattle breed Limousine, simmental, and PO Rp 43,000-45,000/kg. http://ternakdanburung.blogspot.co.id/2017/01/harga-terbaru-2017-sapi-lokal-di-pasar.html

[3] PO cattle live weight varies from 220 kg to 600 kg. http://agoespriyono.blogspot.co.id./2013/04/analisa-usaha-budidaya-ternak-sapi.html.

[4] For one PO cattle care, it requires daily feed: forages = 40 kg x Rp 100 = Rp 4,000; concentrate 3 kg x Rp 1,500 = Rp 4,500; supplementary feed = 3 kg x Rp 200 = Rp 6,000. Total feed per day = Rp 9,100.

Table 14: Total cost estimation per head with assumption that sick cattle is sold

Cost (Rp.)	Unvaccinated village		Vaccinated village	
	Total (Rp)	Cost per head (Rp)	Total (Rp)	Cost per head (Rp)
Mortality rate (%)	101,400,000	390,000	0	0
Morbidity rate (%)	3,766,750	14,488	61,750	238
Weight loss (kg)	1,084,824,000	4,172,400	17,784,000	64,800
Vaccination rate (%)	0	0	11,700,000	45,000
Total	1,189,990,750	4,576,888	29,545,250	113,638

If an infected cattle loses 30% of body weight or equal to 120 kg, there is a decrease of Rp 5,280,000 per head and this requires a feed cost of Rp 1,560,000 per head to regain (see Table 18). The cost difference due to weight loss per head is Rp 4,172,400 in the unvaccinated village compared to Rp 64,800 in the vaccinated one, if it is assumed that sick cattle were sold during the outbreak.

With a vaccination cost of Rp 45,000 per head and 100% vaccination is conducted in the vaccinated village, and then the required total cost is Rp 11,700,000 (Table 14).

If sick cattle are sold then the loss is Rp 1,084,824,000 (Rp 4,172,400 per head) for the unvaccinated village and Rp 17,784,000 (Rp 64,800 per head) for the vaccinated village. Total potential costs that can be saved are estimated at Rp 1,189,990,750 (Rp 4,576,888 per head) for the unvaccinated village and Rp 29,545,250 (Rp 113,638 per head) for the vaccinated village against FMD (Table 14).

Hence, it can be indicated that the difference between total financial costs that can be saved between the unvaccinated and vaccinated village is Rp 1,160,445,000 (Rp 4,463,250 per head). To extrapolate this number into the national level requires an assumption of the number of infected cattle during the outbreak (see Table 15).

Table 15: Estimation of FMD financial costs at national level

Variable	Number	Remarks
No. of infected cattle	201,951	The number assumed incurred in 8-weeks onset of the outbreak (see Chapter III – scenario 3)
Financial costs per head saved at the village level	Rp 4,463,250	The numbers obtained from the above calculation
TOTAL	Rp 901.357.800.750 US$ 69.335.215	

By multiplying the number of infected cattle with the financial costs that can be saved in village level, the financial impact of FMD at national level can be estimated to be Rp 901.4 billion (US$ 69.3 million).

4.2. Impacts on trade

FMD is not only important for local market, but also for international trade. Infected countries are often faced with harsh actions implemented by their trading partners. Countries importing animal products usually impose trade restrictions such as the banning of imports from any country experiencing FMD outbreaks. These measures are also supported by international regulations and control and eradication procedures established by the OIE (Junker et al., 2009).

For a country like Indonesia, which is not a major exporter of livestock and livestock products, the economic impact of trade restrictions of an FMD outbreak incursion is not too significant. Compared to countries like Australia where the economic impacts of an FMD outbreak would be far greater than the cost required to control it. Even if a country is FMD free, if it trades with FMD infected countries it will experience trade restrictions (James and Rushton, 2002).

The costs due to trade restrictions will be more due to FMD-free countries refusing to import meat (or several other agricultural products) from FMD infected countries because of their concerns of importing the disease. This effectively divides the world into two markets – FMD-free market and FMD-endemic market. The commodity price in the FMD-free market is much higher than endemic markets (Productivity Commission, 2002).

FMD-free countries usually tend to protect their domestic agriculture by not importing any livestock and livestock products from infected areas or by making import requirements with a series of strict prevention measures (Otte et al., 2004).

Although Indonesia is a net importer country of livestock and livestock products, there are some commodities in small quantities that are exported to various countries. Indonesia’s exports also affected by an FMD outbreak occurence assumed are the export of sugarcane tops, raw leather, and probably also the export of processed beef.

FMD impact on sugarcane top export

In international markets, Indonesia has exported sugarcane tops to Japan since the 1990’s. When an FMD outbreak errupted in several continents including Europe and Asia in 2001-2002, sugarcane tops export from East Java Province were halted by the Japanese Government, and Indonesia was asked to conduct a survey on matters related to FMD (Baraniah, 2014). The rejection of sugarcane tops exports to Japan due to FMD concerns continued to occur until 2010.

Indonesia has complained about the Japanese ban on sugarcane tops to the World Trade Organization (WTO) based on the risk of FMD since 2005. The Indonesian Government urged that the Japanese Government should recognize Indonesia as free from FMD and lift the ban on imports of sugarcane tops due to FMD risk. Although the trade ban issue is still recorded on the list of specific trade concerns of the WTO Committee on Sanitary and Phytosanitary, it is no longer reported (March 2017) (WTO 2017).

In Indonesia, sugarcane tops are mostly used as feed for cattle and buffalo, especially during the drought season to reduce dependence on the limited pasture (East Java Office of Livestock Services, 2012).

Sugercane tops are obtained from sugarcane plantations in the area of five sugar manufacturers around Sidoarjo and Mojokerto district, East Java province. Both districts are well known as areas of East Java province with extensive sugarcane plantation. The by-products from sugarcane harvest is used as an export commodity. Japan is currently the largest export destination for sugarcane tops, and mostly used as raw material for organic fertilizer on horticulture farms.[5]

The value of sugarcane tops as an export commodity is estimated at US$ 2,500 (Rp 3.3 million) per ton. Total sugarcane production in all areas of Java island in 2016 was 1,742,012 tons and from East Java alone was 1,369,107 tons (Directorate General of Plantation, 2015). It is estimated that from 100 tons of sugarcane, 14 tons of fresh sugarcane tops are available (Sustainable.movement, 2011), therefore from the production of 1,369,107 tons of sugarcane around 191,675 tons of sugarcane tops are available.

[5] https://saraswanti.com/eskpor-pucuk-tebu-ke-jepang/

If Indonesian sugarcane tops export is rejected due to FMD, it is assumed that 10% of East Java's sugarcane tops production cannot be exported. Therefore, the economic losses due to losing the opportunity to export sugarcane tops is around US$ 47.9 million (Rp 622,9 billion).

FMD impact on raw leather exports

The production of raw leather is still insufficient due to the limited livestock population in Indonesia, and causes the price of local leather raw materials to be generally higher than imported ones. This is seen from the phenomenon of a higher leather raw material imports prices compared to exports. Indonesia imports raw leather products that still need to be tanned. The low technology of the raw material production process and the low quantity available are also reasons for Indonesia's lack of flexibility in production.

According to OIE requirements, a country's veterinary authority can allow without restriction, the importation or transit through its territory of semi-processed leather (salted leather, pickled leather, and semi-finished leather - such as wet blue and crust), provided that these products have been passed through chemical and mechanical process commonly used in leather tanning industries. Indonesia has prohibited the import of raw leather, salted leather, and pickled leather from FMD infected countries.

Table 16: Volume and value of Indonesian raw leather export (2016)

HS Code	HS Description	Volume (kg)	Value (US$)
4104110090	Other tanned/crust hide & skin of bovine, full grain, unsplit in the wet state	85	815
4104190000	Other tanned/crust hide & skin of bovine, not full grain, unsplit in the wet state	9,632	52,508
4104410000	Crust vegetable (semi-tanned) hide & skin, full grain, unsplit; in the dry state	726	15,598
4104490000	Other crust vegetable (semi-tanned) hide & skin, full grain, unsplit; in the dry state	196,682	693,212
4105300000	Tanned/crust sheep/lamb skin, w/o wool on /hair on, in dry state	484	35,684
4106220000	Tanned/crust goat/kid hide & skin, w/o wool on/hair on, in the dry state	958	15,090
4106910000	Other tanned/crust hide & skin of other animal, w/o wool on/hair on, in the wet state	6,067	505,584
4107110000	Whole hide & skin, full grains, unsplit of bovine/equine animals, w/o hair on	64	1,766
4107120000	Whole hide & skin, grains splits of bovine/ equine animals, w/o hair on	1,379,150	31,574,321
4107190000	Other whole hide & skin of bovine/equine animals, in other form	1,339,501	34,454,521
4107910000	Other whole hide & skin, including side of bovine/equine animals, full grains	35	125
4107920000	Other whole hide & skin, including side of bovine/equine animals, grain splits	13,546	407,036
	Total	**2.946.930**	**67.756.260**

Source: Indonesian Bureau of Statistics, 2017

The chance of Indonesian leather exports being rejected, particularly salted leather and pickled leather, if an FMD outbreak occurs is likely and would cause an economic impact due to the loss of export opportunities. Table 16 shows the volume and value of Indonesian raw leather export to several countries in 2016.

With the loss of raw leather export opportunities due to FMD, the economic loss is estimated at US$ 67,7 million (Rp 880.8 billion).

FMD impact on meat and processed meat export

Indonesia has a low meat consumption rate of less than 3 kg per year yet imports meat from other countries in significant amounts. To reduce the chance of FMD virus incursion, for a long time Indonesia has only imported from FMD-free countries such as Australia (mostly), New Zealand, the United States and Canada. The price of meat from such sources is much higher. This is essentially an additional cost of FMD control paid to reduce the risk of FMD virus being imported (Knight-Jones and Rushton, 2013).

Table 17: Volume and value of Indonesian beef exports (2016)

HS Code	HS Description	Volume (kg)	Value (US$)
208909000	Meat & edible meat offal of other animals	468,954	2,667,298
210199000	Other meat of swine, salted, in brine,	1,310	408
210200000	Meat of bovine animals, salted, in brine,	226	1,066
201200000	Other cuts with bone in of bovine	180	74
202300000	Boneless of bovine animals, frozen	82	895
203190000	Other meat of swine, fresh or chilled	6,761	7,057
203290000	Other meat of swine, frozen	270,547	584,384
204220000	Other cuts of sheep, with bone in, fresh	109	652
204410000	Carcasses and half-carcasses of sheep,	5	11
206800000	Edible offal of sheep, goats, horses,	230	1,208
206900000	Edible offal of sheep, goats, horses,	1	1
210999000	Other meat & edible, including frours & meals	1,978	1,978
	Total	**750,383**	**3,265,032**

Source: Indonesian Bureau of Statistics, 2017

Table 18: Volume and value of Indonesian processed beef exports (2016)

HS Code	HS Description	Volume (kg)	Value (US$)
1601001000	Sausages & similar products of meat, meat offal/ blood, prepare of it, in air tight container	3,767	7,513
1601009000	Sausages &similar products of meat, meat offal/ blood, not in air tight container	28,733	60,893
1602109000	Homogenised preparation of meat, offal/blood, not contain pork, not in air tight container	455	2,913
1602491100	Luncheon meat of swine, in airtight containers	204	600
1602500000	Other prepared/preserved meat, offal/blood of bovine animals	14,353	21,068
	Total	**47,512**	**92,987**

Source: Indonesian Bureau of Statistics, 2017

FMD impact on meat and processed meat exports can be illustrated by the possibility of a trade ban due to an FMD outbreak. Tables 17 and 18 provide the information on the meat and processed meats exported by Indonesia to several countries in 2016.

In Indonesia growing income levels have increased the demand for meat, causing further increases in the price of meat. High beef prices have resulted in increasing quantities of illegally imported meat from India where FMD is still present but where meat is cheaper. To reduce the price of legally imported meat and meet the needs of domestic meat demand, the Indonesian government has relaxed the regulations by allowing imports not only from FMD free countries but also FMD-free zones in countries that are still endemic with FMD (Knight-Jones and Rushton, 2013).

FMD impact on meat and processed meat exports can be assumed to be the total meat export value of US$ 3.3 million (Rp 42.4 billion) and processed meat of US$ 92,9 thousand (Rp 1.2 billion), thus the economic losses are estimated to be US$ 3,4 million (Rp 43.6 billion).

4.3. Impacts on industry

FMD has considerable effects not only on the agricultural industries but also on the tourism sector due to major reductions in tourism demand, therefore the effects of the ways in which the government handles the outbreak is very important (Blake et al., 2003).

The cost of the outbreak to the UK economy in 2001, including losses incurred in agriculture and tourism have been estimated at US$ 11 billion, and nearly 7 million animals or about 12% of all livestock were slaughtered. However, domestic consumption of red meat in the UK 3 years after the outbreak was unaffected. The most affected were red meat exports that suffered a substantial reduction during the FMD outbreak and the following years (Oladosu et al., 2013).

In economic theory, the indirect impacts of infectious animal diseases include the so-called ripple effects, spill-over effects and costs to wider society which are the long-term macro-economic impacts (Agra CEAS Consulting, 2007). The indirect impacts are described as follows:

- *Ripple effects* include impacts on livestock and livestock products price, and upstream and downstream activities along the cattle value chain. For example, the value chain for cattle is complex and includes various upstream and downstream activities such as breeding, feed production, input supply (livestock seeds, feed, veterinary medicine, etc.), slaughtering, processing, final sales and consumption.
- *Spillover effects* include impacts other than to the agricultural sector, such as on tourism and the sectors related to public services. The macro-economic impact can be large if these two sectors are important in a country's economy. In addition, infectious animal diseases can also have large effects on the availability and quality of food for the poor and therefore can lead to food security issues, as well as the negative effects on poverty reduction.
- *Effects on wider society* can include exposure to zoonotic risk, which is a threat to public health. Particularly in the case of a pandemic where the proportion of large economic losses is due to the higher morbidity and mortality rates in human population and its effects on the world economy. FMD is not a zoonosis, so the effect on the wider community should not be considered.

To estimate the three effects mentioned above is not simple, due to the complexity of factors involved and constraints such as methodological difficulties, extensive data requirements for analysis, and data regarding costs that are rarely explored in depth in the available literature (Agra CEAS Consulting, 2007).

FMD impact on domestic prices

Two ripple effects that may be relevant if an FMD outbreak occurs in Indonesia are the decline in domestic beef prices and the decline in beef domestic sales. An example is the occurrence of avian influenza outbreaks in 2004-2005 in Indonesia, where indirect impacts resulted in a decreased price for commercial broiler and layer chicken (Agra CEAS Consulting, 2007).

An analysis of the FMD impact on short-term animal prices was also made in Korea after experiencing two outbreaks, first in 2000 and second in 2002. After the first outbreak, the prices of pigs, pork and beef fell by 15-20% before the government began an intervention program. Although the second outbreak resulted in more deaths than the first, the effect on the price was much smaller. This was possibly caused by the government's response to the first outbreak which set a precedent for the second outbreak. The rapid decline in pig prices, coupled with a decrease in the number of pigs sold, has a significant financial impact on farmers (Roh et al., 2006).

The total net impact on domestic and international markets depends on the outbreak impact on consumer demand and the price level as well as the proportion of affected producers (Agra CEAS Consulting, 2007).

To estimate the cost resulting from the decline in prices in this calculation, it is assumed that after the FMD outbreak, cattle prices decreased by 20% and beef price declined by 15%. This figure refers to the numbers acquired during FMD outbreak in the UK in 2001, although it may also be less precise because the magnitude of the FMD outbreak in the UK was huge and the impact of culling 2.6 million heads elicited an enormous reaction from British society, including criticism on animal welfare (Thompson et al., 2002).

Table 19: Estimation of the decrease of cattle price and beef sales

Parameter*	Amount
Normal state (before the outbreak)	
Total cattle population	16,092.560 heads
Percentage of adult cattle 2-4 years	18.15%*
Percentage of cattle sold	11%***
Number of adult cattle 2-4 year	2,920,800 heads
Number of beef production	524,110 tons
Average price of adult cattle per head	Rp 14,500,000
Average beef price per kg	Rp 116,421**
Total of cattle value	Rp 4,658,675,425,800 (US$ 358 million)
Total of beef value	Rp 61,017,410,310 (US$ 4.6 million)
Assumption after FMD	
Percentage of cattle price decreased per head	20%
Cattle price per head after decrease	Rp 11,600,000
Percentage of beef price decreased per kg	15%
Beef price per kg after decrease	Rp 95,958
Value lost due to cattle price decreasing by 20%	Rp 931,735,200,000 (US$ 71.7 million)
Value lost due to beef price decreasing by 15%	Rp 10,724,862,930 (US$ 825,000)
Total value due to decrease in cattle price and beef price	Rp 942.460.062.930 (US$ 72.5 million)

* Livestock and and Animal Health Statistics, 2017
**Indonesian Ministry of Trade, 2017
*** Putra, 2017

The economic loss from the decrease of live cattle prices is estimated to be Rp 931.7 billion (US$ 71.7 million) and from the reduction of beef price estimated to be Rp 10.7 billion (US$ 825,000) – so in total Rp 942.5 billion (US$ 72.5 million) (see Table 19).

FMD impact on tourism industry

The result of the analysis using Computable General Equilibrium (CGE) model of the tourism sector in the UK shows that the FMD impact on tourism was much greater than on the agricultural sector, therefore when assessing the FMD economic impacts it is necessary to consider the direct and indirect impacts of an FMD outbreak (Blake et al., 2003).

An analysis was conducted to estimate the economic costs to the tourism industry in the UK after the FMD outbreak in 2001. Based on tourism survey data, businesses directly affected by both domestic and foreign tourists expenditure were estimated to suffer losses of between £2.7 million and £3.2 million (Rp 46.8 billion and Rp 55.6 billion) as a result of the declining number of tourists (Thompson et al., 2002). During the FMD outbreak, the British Hospitality Association estimated a 10% drop in the number of foreign tourists coming to UK in that year (Countryside Agency, 2001).

The contribution of the tourism sector to the Indonesian economy in 2015 is estimated to be 4.23% or Rp. 461.36 trillion (Indonesian Ministry of Tourism, 2016). In estimating the FMD spill-over effects on the tourism sector, it is assumed that the emergence of FMD outbreaks will cause a decline in the number of foreign tourists by 10%. The cost from lost tourism revenue at national level is the number of foreign tourists (only visitors' arriving at the international airports of Ngurah Rai in Denpasar and Juanda in Surabaya are considered) multiplied by the average expenditure per visit.

Table 20: Estimation of FMD impact on tourism sector

Parameter*	Amount
Normal state (before the outbreak)	
Number of foreign tourists	4,140,266 people
Average foreign tourist expenses per visit	US$ 1,208.8
Cost obtained from foreign tourists	US$ 5,004,712,138 (Rp 65.1 trillion)
Assumption after FMD outbreak	
The decline in the number of foreign tourists	10%
Number of declined foreign tourists	414,027
Cost due to the decline in the number of foreign tourists	US$ 500,471,214 (Rp 6.5 trillion)

***** Based on 2015 data
Source: Indonesian Statistics, 2016

The lost of revenues due to the decline of foreign tourists visits to Indonesia is estimated to be US$ 500.5 million (Rp 6.5 trillion) (see Table 20).

4.4. The Economic Losses in FMD-Free Status

Estimation of the economic and financial benefits of FMD-free status at the national level, including include direct impacts or short-term impacts, and also indirect impacts or long-term impacts (such as losing confidence in government, losing the consumer's confidence, and trade and tourism reactions). Indirect impacts or long-term impacts are usually greater than direct impacts or short-term impacts.

A factor generally contributing significantly to direct cost in developed countries is the rapid response and reaction to the crisis. Such factors are less likely to be implemented in developing countries such as Indonesia – it is recognized that there is a wide variation between countries.

To get an estimate of these benefits, the various impacts indicated above are summed up to produce the total costs that can be saved if there is no FMD case. The disadvantage of obtaining such an estimate is not using the available economic models and relying solely upon the assumption-based references that refer to other countries which have experienced outbreaks of FMD.

The total costs that can be gained from FMD-free state in a year as shown in Table 21 is Rp 9.9 trillion (US$ 761.3 million). This indicates that the indirect impact such as on tourism which is the spill-over effect incurs 66% or more than half of the total indirect impacts. If the indirect impacts which are the overflow effects added with the ripple effect, then both incur 91% proportion. If all industries and trade related to agricultural sector are accounted for, then the proportion is 25%.

Table 21: Estimation of FMD economic impacts at national level

Impacts	Costs in Rp	Costs in US$
FMD financial impacts at national level	901.4 billion	69.3 million
FMD impacts on sugar cane tops export	622.9 million	47.9 million
FMD impacts on raw leather export	880.8 billion	67.7 million
FMD impacts on meat and processed meat export	43.6 billion	3.4 million
FMD impacts on domestic prices	942.5 million	72.5 million
FMD impacts on tourism industry	6.5 trillion	500.5 million
Total	**9.9 trillion**	**761.3 million**

This is almost aligned with the analysis of FMD outbreak impacts in the UK in 2001 by Blake et al. (2003), where the results showed that FMD outbreak have a huge effect to GDP through the decline in tourism revenues compared with other effects.

CHAPTER V

FMD PREPAREDNESS COSTS

To maintain its 25 years FMD-free, Indonesia needs to develop effective emergency preparedness and response to protect its livestock assets and economy. To mitigate the risk from an FMD outbreak, a country should have effective emergency management plans which are well-resourced and always ready to be activated at all levels of the government, by the private sector and in the community. Institutions involved in the response include the ministries in charge of health and conservation, local governments, police, disaster relief agencies and other non-governmental organizations.

5.1. The importance of a Preparedness Plan

The importance of a preparedness for Indonesia is also influenced by changes in its meat import policies. Since the end of 2016, Indonesia has begun to revamp its policies to reduce the high beef price of Rp 135,000 - Rp 150,000 (US$ 10.1 - US$ 11.2) per kg by allowing the import of frozen boneless buffalo meat from India, a country still infected with FMD. The import volume and value of frozen boneless buffalo meat from India in 2016 and 2017 can be seen in Table 22.

Table 22: Volume and value of frozen boneless buffalo meat import from India

	2016	2017	Total
Volume (tons)	812	65,808	66,620
Value (US$)	2,363,974	229,823,747	232,187,721

Source: APEDA, 2017

The import of Indian buffalo meat began at the end of August 2016. Many parties in the country as well as from Australia, a neighbouring country, are very alarmed at the import of Indian buffalo meat, as this increases the risk to Indonesia of an FMD incursion – and this is also a threat to neighbouring countries. The magnitude of the risks and the potential economic impact of FMD determine the level of investment needed to protect a country's territory from the FMD threat. Therefore, Indonesia needs to improve its preparedness to a more higher level.

As an FMD-free country for almost three decades, it is necessary to conduct studies on the possibility of FMD virus entering Indonesia considering factors such as the weaknesses of the national animal health system in mitigating the risk, responding to an outbreak and reducing the cost of an FMD outbreak.

Some assumptions are provided here on the likelihood of what will be happen if an FMD outbreak occurs in Indonesia as follows:

1) The FMD outbreak is not detected quickly (within a few days), so it could have already spread significantly into a wider area.
2) The outbreak control actions which require the support of the legal power (e.g. culling and compensation) are delayed or difficult to perform according to international standard procedures, due to the weak regulations regarding contagious animal disease outbreaks as well as the ability for implementation both at the national and local levels.
3) The capacity of the response is not sufficient to manage such an FMD outbreak with a magnitude far greater than other infectious animal diseases, so the response of the central and local governments as well as the livestock community tends to be overwhelmed by the emergency outbreak.

4) The capacity of the human and physical resources to conduct the destruction and disposal of livestock on a large scale remains questionable given Indonesia has limited experience and the way it is handled is also likely to be criticized by the livestock community and/or animal lovers.
5) Regaining freedom status after an FMD outbreak is difficult to achieve within 3 or 6 months, as recommended by OIE, following the appropriate actions for controlling the outbreak as these may not be effective or not comply with the principles of emergency response.

For an FMD preparedness plan that are ready to be activated if an outbreak occurs at any time, it is necessary to set the goals and strategies of the preparedness to be implemented by Indonesia. The anticipation in the form of preparedness activities is also Indonesia's contribution to the global FMD control "Progressive Control Pathway for FMD" (PCP-FMD) developed by FAO and OIE (Fukase, 2012).

Table 23 below lists the preparedness-related aspects that need to be prepared to be able to detect, investigate and respond to an FMD outbreak effectively.

Tabel 23: Preparedness activities for FMD

Approach	Activities
Authority	- Policy and regulation regarding infectious animal disease* and veterinary authority**. - Outbreak reporting the authority of local government. - Response to the exotic disease outbreak is the responsibility of central government. - Veterinary authority local official must be appointed and assigned by the Governor/Regent/Mayor.
Planning	- Preparation of an FMD Preparedness Plan (known as FMD Indonesian Veterinary Emergency Preparedness/Kiatvetindo PMK)
Surveillance	- Sampling and analysis for surveillance to maintain freedom state conducted annually and as required for suspect outbreaks. - Surveillance focus on areas predicted as high risk (border areas, areas with high animal and animal products traffic, and areas with high cattle density).
Simulation exercise	- Simulation exercises are required, as stipulated by Ministerial Regulation, to be conducted annually. - Implementation in the form of a table-top simulation twice a year at the minimum in different areas. - Local governments conduct simulation for their territories.
Communication and Public awareness	- Policy on specific suspect disease reporting for FMD through iSIKHNAS - Media preparation as printed media (brochures, leaflets, posters, booklets, etc.), electronic media, etc. - Placing commercial in radio, TV or social media.
Investigation (before the outbreak is confirmed)	- Diagnostic preparation of the FMD laboratory with the following detection capabilities: • FMD antibody with ELISA (5-18 hours); • FMD antibody against non-structural protein (NSP) from FMD virus with 3ABC ELISA (4-5 hours); • FMD antigen in form of viral protein using double antibody sandwich ELISA (4 hours) or viral nucleic acid with RT-PCR (in 1 day). - Implementation of laboratory preparedness to undertake field sampling and FMD sample diagnostics can be conducted within the time specified in the standard procedure.

Vaccination	- A policy indicating when vaccinations are to be implemented during an outbreak should already be established considering a range of factors. - Preparation of specific plans for the supply of vaccine during the outbreak, including matching strains, import permits and registration. - Preparation of a communication plan to obtain the necessary vaccine during an outbreak from an OIE vaccine bank (see Box 2). - An alternative is the preparation of a plan to contract an international FMD vaccine manufacturer to provide commercial vaccines.
Zoning	- Preparation of zoning plans (infected zone, buffer zone, vaccination zone, surveillance zone and free zone) as control areas to control the spread of the infection.
Quarantine and movement control	- Preparation of livestock movement restriction plans based on zone in coordination with the police and local transportation agency. - Preparation of policies to stop traffic or movement in and out of infected zones for all livestock susceptible to FMD (cattle, goats, sheep and pigs) within a certain time (the latest 21 days) after an FMD outbreak confirmation. - Preparation of criteria as the basis for closure or opening the outbreak area based on the instruction of Governor/Regent/Mayor.
Incident Command System	- Preparation of responses that are required from the local veterinary authorities using the Incident Command System (ICS). - Preparation of field operations by the Rapid Response Unit (URC) team in coordination by the ICS. - Preparation of coordination and communication with National and Regional Disaster Management Agency (BNPB and BPBD) by following their mandate and the principles of disaster management.
Traceability	- Preparation of livestock movement policies applicable in the buffer zone, vaccination zone, surveillance zone and free zone which require that every movement must be permitted with an animal health certificate stating that the livestock is healthy after a clinical examination.

Note:

* Law of the Republic of Indonesia Number 18 of 2009 jo Law Number 41 of 2014 regarding Animal Husbandry and Animal Health.

** Republic of Indonesian Government Regulation Number 47 of 2014 regarding Control and Counter Measure of Animal Disease.

5.2. FMD Vaccines and Vaccination

Indonesia no longer produces FMD vaccine (some FMD-free countries do produce FMD vaccine). So isolates of FMD virus taken from the field must be sent overseas to be characterized and/or made into a vaccine by a manufacturer. The most likely means of rapid access to vaccine by Indonesia is to obtain assistance from the OIE vaccine bank (see Box 2).

Vaccination of susceptible animals against FMD is a well established strategy for helping to combat the disease. Traditionally, FMD vaccine has been used to control a disease incursion in countries where the disease has been endemic rather than in countries considered free of the disease (Khan et al, 2002). In case of Indonesia where culling measures are difficult to implement, the option for a limited vaccination program has therefore to be reinvented at the early stage of an FMD outbreak.

Selection of field viruses for vaccine matching is particularly important in any FMD outbreak. More than one representative isolate should be evaluated from an outbreak. Viruses should be selected based on epidemiological information, for instance isolation at different stages of an outbreak, from different geographical locations, or from different hosts (OIE Manual, 2017).

BOX 2: OIE Vaccine Bank

OIE is globally experienced in managing vaccine banks and deliveries for Avian Influenza (AI) vaccines, Foot and Mouth Diseases (FMD), Rabies (vaccinations for dogs), and Peste des Petits Ruminants (PPR). The OIE vaccine bank is financially supported to date by Australia (FMD and Rabies), Canada (AI and Rabies), China (FMD), European Union (Rabies and FMD), Germany (Rabies) Korea (FMD), New Zealand (FMD) and Bill & Melinda Gates Foundation (PPR). The OIE vaccine bank is built through an international tender and selection procedure that includes an independent committee of internationally recognized experts and donor representatives.

High-quality vaccines that meet international standards are provided free of charge for developing countries to destination airports (vaccine and transportation costs borne by vaccine banks). The recipient country may concentrate on its limited efforts and resources in conducting vaccination campaigns ('in kind' contributions and mobilization of human, financial and technical resources, such as vaccinators, cold chain and storage when necessary, and consumable equipment for vaccination), or in form of public-private partnership contract, for example with non-government organisations.

Regional OIE vaccine/antigen banks include ready-to-use vaccines, formulated vaccines that can be delivered on time if there is urgent demand. Production can also be organized on demand by replenishment mechanism in order to meet the different needs of various parties, regardless of the the size (small or large) of these needs. This mechanism enables rapid supply of emergency stocks to recipient countries, as well as lower cost delivery plans, in order to vaccinate population target at risk and to achieve progressive eradication where feasible.

Source: http://www.oie.int/support-to-oie-members/vaccine-bank/

If the vaccine must be purchased from an international vaccine manufacturer, then the vaccine price includes procurement cost which varies between US$ 0.40 - US$ 3.0 (Rp 5,300 - Rp 40,000) per dose (Rushton and Knight-Jones, 2012). To date all FMD vaccines used worldwide are inactivated vaccines (Park, 2013). The development of FMD vaccine worldwide in the last 40 years has shown no significant improvement, although oil adjuvant has often been replaced with alhydrogel-based aluminum (Paton and Taylor, 2011).

In an emergency, vaccination policies should be established as soon as possible to avoid delays in handling outbreaks. It should also be noted that the selection of vaccine strains is not only influenced by small cross-protection capabilities between serotypes, but also genetic and antigenic variations between serotypes (Brückner and Saraiva-Vieira, 2010). Therefore, Indonesia needs the support of bilateral and international cooperation to accelerate the process.

In this study, a hypothetical FMD outbreak is assumed to occur in Probolinggo district and this may result in all cattle and buffaloes in the district being vaccinated to prevent transmission to other areas. Therefore, it is assumed that there should be standby or emergency funds for vaccine purchases which can be used at any time in cases of an FMD outbreak emergency. The cost of a vaccination unit per head is estimated at Rp 45,000 (including vaccinator, equipment and operational costs). Assuming that all cattle and buffaloes that need to be vaccinated in an emergency response requires a total of 250,000 heads, so a contingency fund of Rp 11.25 billion (US$ 865.385) is required.

5.3. FMD Diagnostics

Early isolation of FMD virus is very important in confirming and characterizing a suspect outbreak, so the Indonesian laboratory capability must be available. The Center of Veterinary Biologics (Pusvetma) has been established as the national reference laboratory for FMD. All samples of suspected FMD from the field must be sent to Pusvetma for diagnosis and confirmation.

In an FMD outbreak, additional resources, such as personnel and materials, may be needed for sample collection. Additional capacity may also be required for laboratory sample testing. Pusvetma and all the regional laboratories throughout Indonesia have the capability to conduct rRT-PCR tests. These laboratories ideally should also have the capability to conduct 3ABC ELISA serology testing and to differentiate between infected and vaccinated animals (DIVA testing) on a herd basis if required during the outbreak response and follow-up surveillance.

DIVA testing is also required to assess the progress of the vaccination program during and after outbreak. Detection with ELISA of an antibody response to the non-structural protein (NSP) 3 ABC is the most reliable indicator to detect previous infection. NSP ELISA is an easy test to use and is suitable for large-scale applications in routine laboratory serologic surveillance (EU, 1999).

Table 24: FMD reagent prices

Type	Price
Inactivated antigen (e.g. to detect ELISA antigen)	£46/ml (Rp 805,000)
Positive bovine serum	£64/serum (Rp 1,120,000)
Negative bovine serum	£53/serum (Rp 932,000)
Reference Sera	£94/serum (Rp 1,655,000)
NSP	£100/serum (Rp 1,758,000)

Source: The Pirbright Institute, 2017

Table 24 lists the cost of diagnostic kits necessary for detection of the FMD virus and gives indicative figures that Pusvetma needs for preparation and the funding capacity required to purchase adequate reagents and kits.

5.4. FMD Surveillance

Surveillance is a critical activity during an outbreak of FMD. Surveillance helps to identify and contain the spread of the disease and supports the eradication. It is difficult to recommend a single surveillance sampling scheme for an FMD outbreak because many factors impact affect the nature and characteristics of the outbreak. Each outbreak is different; surveillance plans will need to be tailored to individual outbreaks (USDA, 2014).

The preparedness activities should involve the necessary syndromic and passive surveillance to enable to detect of any suspected outbreak rapidly and effectively. Therefore, there have to be a particular emphasis to early detection by strengthening the epidemiological skills and laboratory capacity, and the integration of the information systems of the Indonesian Veterinary Services.

With FMD-free status, Indonesia now focuses on serological surveillance to justify a free status that meets the requirements set forth in the OIE Code and OIE Manual. The important thing in conducting such serological surveillance is how to obtain a representative sample (Caporalle et al., 2012). Assuming that 10% of the total number of villages in Indonesia (a total of 82,253 villages and sub-district), the average population of cattle and buffalo per village is 500 heads, and from the villages as epidemiological unit samples are taken randomly at 1%, the rough estimated number of samples needed is 8,000 samples per year.

To obtain unit costs for sero-surveillance is difficult because of the lack of accurate data, so in this case the same figure is used as estimated by Benigno et al., 2006 for the Philippines which is US$ 30 (Rp 400,000) per serum (including salary, reagents and other operational costs in the laboratory). Thus, it is estimated that sero-surveillance costs require Rp 3.2 billion (US$ 246.154) per year.

5.5. Preparedness Costs

Some of the approaches and strategies mentioned above require a preparedness budget in normal or peace time (before the outbreak). Any outbreak response will depend on the circumstances surrounding the outbreak, including but not limited to the outbreak epidemiology, diagnostic capacity and capability, response strategies, social and political issues, and resources (USDA, 2015).

Table 25 lists the costs required for FMD preparedness in Indonesia to minimize the risk of incursion due to the importation of cattle and animal products.

Table 25: Estimation of annual cost required for FMD preparedness

Preparedness activities	Unit Cost (Rp)	Cost Estimation	Remarks
Sero-surveillance (8.000 samples/year)	Rp 400,000 per sample	Rp 3,200,000,000 (US$ 246,154)	Unit cost including diagnostic kit, equipment, quality assurance, and training.
Simulation (100 person/year)	Rp 6,000,000 per pax	Rp 600,000,000 (US$ 46,154)	Unit cost including logistic, travel, accommodation and material.
Outbreak investigation (conducted 3 times each year with sampling of approximately 100 samples)	Rp 1,200,000 per sample	Rp 360,000,000 (US$ 27,692)	Contingency cost required to conduct outbreak investigation including sending samples to laboratory.
Vaccination (250,000 heads)	Rp 45,000 per dose	Rp 11,250,000,000 (US$ 865,385)	Contingency cost to purchase vaccines if outbreak occurs. Unit cost includes operational.
Communication and public awareness improvement (1.000 village/year)	Rp 300,000 per village	Rp 300,000,000 (US$ 23,077)	
Quarantine and traffic control (40.000 heads/year)	Rp 25,000 per head	Rp 1,000,000,000 (US$ 76,923)	
Outbreak Command Center (25.000 heads)	Rp 15,000 per head	Rp 375,000,000 (US$ 28,846)	Emergency funds if outbreak occurs to establish Outbreak Command Center in outbreak area and the operational of URC team.
Identification and livestock database (livestock traceability) (15.000 heads)	Rp 150,000 per head	Rp 2,250,000,000 (US$ 173,077)	Cost to build database and electronic devices required for livestock identification.
	Total cost	Rp 19,335,000,000 (US$ 1.5 million)	
	Total comtingency cost	Rp 11,610,000,000 (US$ 893,077)	
	Total required cost	Rp 7,725,000,000 (US$ 594,231)	

FMD preparedness costs per year as presented in Table 25 need to be considered against the benefits that can be gained to justify the allocating of funds. The total required preparedness cost is exceeded by the estimated total economic losses if an FMD outbreak occurs in one species in one district in East Java province as described in Chapter 3. This preparedness cost can also be justified in comparison with the overall potential economic losses caused by FMD at the national level as indicated in Chapter 4.

All countries that are free of FMD, such as the Australia, New Zealand, U.S.A. etc. incur prevention and emergency preparedness costs. Some published studies indicate that where FMD eradication is feasible, this is the least expensive policy option, even allowing for the costs of prevention, emergency preparedness and the risk of outbreaks.

The investment in prevention and preparedness is a prudent insurance policy against the potential losses of an FMD outbreak. Therefore, it is a requirement for the Government of Indonesia to ensure continuing refinement and strengthening of FMD preparedness and response arrangements into the future.

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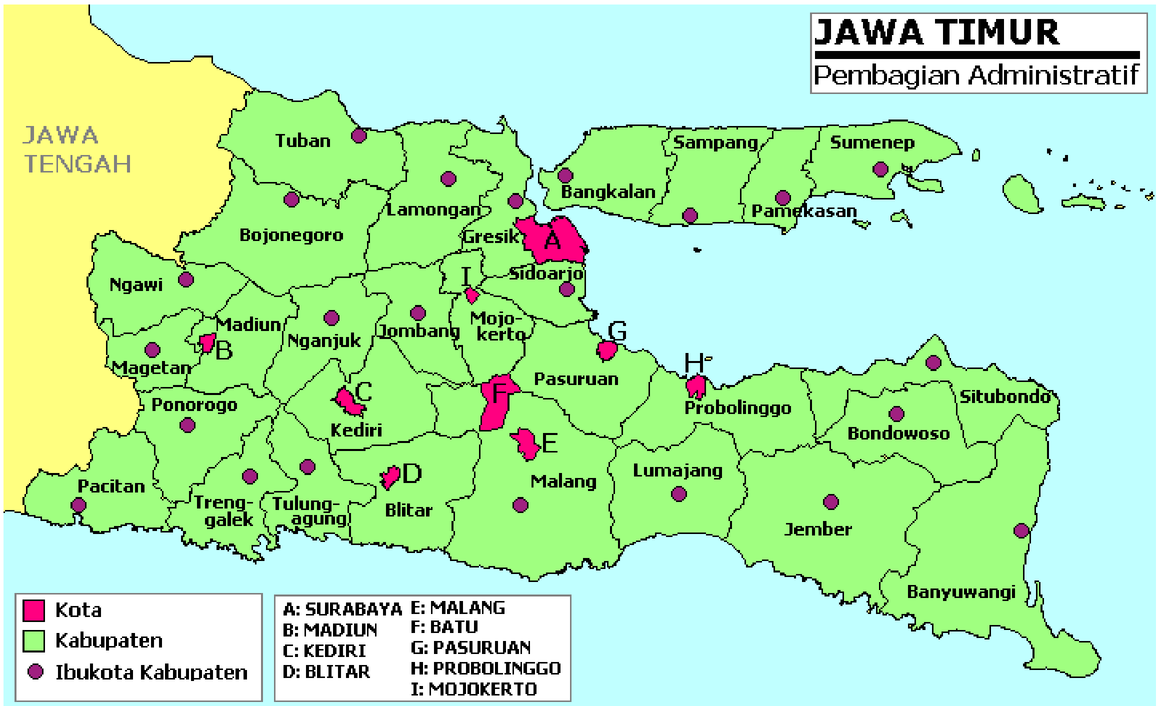
APPENDICES

APPENDIX 1.

Map of East Java and Number of Livestock Susceptible to FMD in East Java Province

Map of East Java Province



Number of livestock susceptible to FMD in East Java Province (2016)

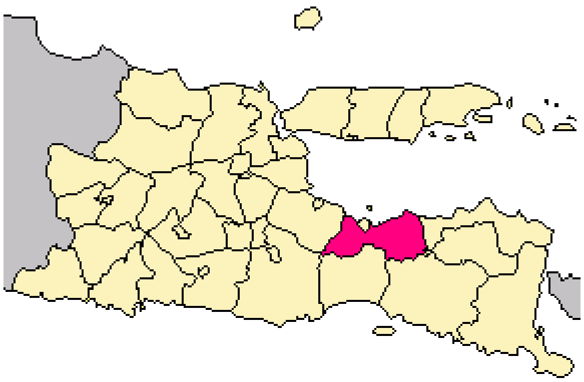
Districts/Municipalities	Beef cattle	Dairy cattle	Buffaloes	Goats	Sheeps	Pigs
District						
01. Pacitan	84,393	147	117	147,800	29,667	-
02. Ponorogo	82,102	2,177	115	194,584	20,927	250
03. Trenggalek	33,887	5,190	256	383,369	10,398	5
04. Tulungagung	111,016	25,229	428	191,915	6,818	10,778
05. Blitar	141,347	14,941	2,012	139,401	7,468	6,600
06. Kediri	212,376	9,766	371	139,369	43,322	2,538
07. Malang	223,717	81,150	1,150	248,048	33,284	13,262
08. Lumajang	194,049	4,989	4,797	103,645	40,904	2,588
09. Jember	250,112	1,451	288	51,264	75,060	454
10. Banyuwangi	115,386	729	3,664	118,068	98,918	616
11. Bondowoso	215,184	31	-	43,898	38,723	-
12. Situbondo	176,398	218	280	73,780	88,324	-
13. Probolinggo	262,408	6,750	46	61,646	72,789	-
14. Pasuruan	106,252	86,847	248	71,179	64,061	-
15. Sidoarjo	9,802	3,632	556	32,169	31,359	-
16. Mojokerto	54,575	2,692	495	51,096	24,371	355
17. Jombang	70,448	4,773	297	122,269	65,634	17
18. Nganjuk	138,601	4	717	122,768	62,751	1,149
19. Madiun	59,518	197	366	72,613	22,244	380
20. Magetan	110,228	236	156	38,376	33,380	9,426

Districts/Municipalities	Beef cattle	Dairy cattle	Buffaloes	Goats	Sheeps	Pigs
21. Ngawi	82,197	34	1,108	82,763	44,300	875
22. Bojonegoro	201,954	36	957	122,961	153,264	-
23. Tuban	329,272	127	1,625	127,898	89,533	301
24. Lamongan	104,779	34	385	102,115	83,527	-
25. Gresik	52,858	449	224	70,029	33,017	-
26. Bangkalan	200,279	20	1,290	73,003	2,232	-
27. Sampang	212,776	-	-	46,182	9,360	-
28. Pamekasan	190,635	8	-	66,398	22,104	-
29. Sumenep	357,422	-	5,051	150,156	38,961	-
Municipality						
30. Kediri	3,686	222	134	2,442	2,491	-
31. Blitar	3,076	309	-	3,601	738	376
32. Malang	3,708	187	56	1,116	383	-
33. Probolinggo	9,592	217	-	7,703	8,886	-
34. Pasuruan	379	17	-	2,892	728	-
35. Mojokerto	145	-	5	1,660	1,110	15
36. Madiun	306	21	8	2,899	978	-
37. Surabaya	223	561	82	1,892	282	-
38. Batu	2,721	11,611	20	6,765	8,582	258
East Java	**4,407,807**	**265,002**	**27,304**	**3,279,732**	**1,370,878**	**50,243**

Source: East Java Provincial Livestock Office, 2017

APPENDIX 2.

Location of Probolinggo District and Number of Susceptible Livestock to FMD in Probolinggo District



Geographical area	1,696,17 km^2
Human population	1,127,950
Number of subdistricts	24
Number of villages	325 villages 5 urban villages

Ruminant population and livestock raising units in Probolinggo District (2013)

Subdistrict	Dairy cattle	Beef cattle	Buffaloes	Goats	Sheeps	Livestock Households	Livestock Corporations
1. Sukapura	84	4,589	0	1,007	1,15	3,18	1
2. Sumber	321	6,434	0	1,437	2,04	4,502	1
3. Kuripan	0	10,902	0	5,105	1,713	6,219	1
4. Bantaran	0	17,646	0	3,259	5,783	8,135	1
5. Leces	551	11,386	0	4,698	8,011	6,048	1
6. Tegalsiwalan	18	10,362	0	1,544	196	5,688	1
7. Banyuanyar	13	4,877	0	1,648	2,149	5,699	1
8. Tiris	189	21,131	0	3,981	2,175	12,463	1
9. Krucil	5,787	22,234	0	1,556	5,307	11,147	1
10. Gading	11	11,085	0	516	1,729	7,368	1
11. Pakuniran	4	10,099	0	339	1,555	663	1
12. Kotaanyar	0	11,390	0	465	3,592	5,999	1
13. Paiton	0	9,582	0	735	834	7,141	1
14. Besuk	0	6,506	0	482	1,301	4,037	1
15. Kraksaan	0	2,876	48	375	458	1,734	1
16. Krejengan	1	3,260	5	17	670	2,913	1
17. Pajarakan	157	1,178	1	1,169	122	1,376	1
18. Maron	12	9,660	2	1,084	1,064	5,428	1
19. Gending	26	1,473	4	666	845	1,687	1
20. Dringu	0	2,752	12	5,891	10,486	3,107	1
21. Wonomerto	0	14,871	0	2,321	2,635	7,729	2
22. Lumbang	158	12,280	0	1,343	2,114	6,583	1
23. Tongas	67	22,791	0	4,973	5,112	1,069	2
24. Sumberasih	0	10,200	0	115	26	5,988	1
Total	**7,399**	**239,564**	**72**	**48,812**	**65,405**	**141,491**	**26**

APPENDIX 3.

Calculation of FMD economic impacts

Total economic losses if FMD outbreak occurs is expressed as the following:

Economic Losses = A + B + C + D + E + F + G + H + I + J + K + L

A = Loss due to adult cattle deaths
B = Loss due to young cattle deaths
C = Loss due to abortion
D = Loss due to decreased calf growth
E = Culling Cost
F = Compensation cost
G = Vaccination cost
H = Cold chain and field officer training cost
I = Movement restriction cost
J = Surveillance cost
K = Control management cost
L = Information, Education and Communication (IEC) cost

The syntax for each of the components used in the calculation are presented in Table X below:

Table X: Parameters used in the calculation of FMD economic impact

No.	Components	Syntax
1.	Beef cattle population in the affected area	TPB
2.	Number of villages in the affected area	VAA
3.	Estimated number of infected cattle in the affected area	IP
4.	Percentage of bull population	%BP
5.	Percentage of cow population	%CP
6.	Percentage of steer population	%SP
7.	Percentage of heifer population	%HP
8.	Percentage of male calf population	%MP
9.	Percentage of female calf population	%FP
10.	Estimated adult cattle mortality rate	%AM
11.	Estimated young cattle mortality rate	%YM
12.	Estimated number of bull deaths due to FMD	BD
13.	Estimated number of cow deaths due to FMD	CD
14.	Estimated selling price of bull per head	RpB
15.	Estimated selling price of cow per head	RpC
16.	Estimated selling price of young cattle per head	RpY
17.	Estimated selling price of calf per head	RpF
18.	Estimated number of young cattle death due to FMD	YD
19.	Estimated number of calves lost due to abortion	CA
20.	Pregnancy rate of cow	%PR
21.	Estimated abortion rate due to FMD	%AR
22.	Percentage of decreased calf growth	%DC
23.	Estimated number of calves with decreased growth	CG
24.	Estimated culling rate	%CR

25.	Estimated number of adult cattle being culled	CL
26.	Estimated compensation payment per head	%CH
28.	Percentage of vaccinated cattle	%TVC
29.	Estimated vaccine cost per head	RpVC
30.	Estimated operational vaccination cost per head	RpOVC
31.	Estimated number of vaccinated adult and young cattle	VAY
32.	Estimated vaccinator operational cost per person	RpVOP
33.	Time needed for control outbreak in months	TOM
34.	Estimated number of vaccinator required per month	VR
35.	Estimated number of field officer training required	NFT
36.	Estimated cost for field officer training	RpFOT
37.	Estimated cold chain investment cost	RpICH
38.	Estimated surveillance cost per investigation	RpSI
39.	Estimated surveillance operational cost per investigation	RpOSI
40.	Estimated sample delivery cost to reference laboratory	RpRL
41.	Estimated number of investigation performed	SP
42.	Estimated border control cost per head	RpBCC
43.	Estimated quarantine disinfection cost per head	RpQDC
44.	Estimated control management cost per village	RpCMC
45.	Estimated IEC cost per village	RpIEC

A. Loss due to adult cattle deaths

Loss due to adult cattle deaths (A) is calculated from the due to FMD (BD) multiplied by estimated selling price of bull per head (RpB) plus (CD) multiplied by estimated selling price of cow per head (RpC), with the following formula:

$$A = (BD \times RpB) + (CD \times RpC) \quad (1)$$

Estimated number of bull deaths (BD) due to FMD is obtained from the percentage of bull population (%BP) multiplied by estimated number of infected cattle in the affected area (IP) then multiplied by estimated adult cattle mortality rate (%AM), with the following formula:

$$BD = \%BP \times IP \times \%AM \quad (2)$$

Estimated number of cow deaths due to FMD (CD) is obtained from the percentage of cow population (%CP) multiplied by estimated number of infected cattle in the affected area (IP) then multiplied by adult cattle mortality rate (%AM), with the following formula:

$$CD = \%CP \times IP \times \%AM \quad (3)$$

B. Loss due to young cattle death

Loss due to young cattle death (B) is calculated from the estimated number of young cattle death due to FMD (YD) multiplied by estimated selling price of young cattle per head (RpY), with the following formula:

$$B = YD \times RpY \quad (4)$$

Estimated number of young cattle death due to FMD (YD) is obtained from the percentage of steer population (%SP) plus the percentage of heifer population (%HP) multiplied by estimated number of infected cattle in the affected area (IP), then multiplied by estimated young cattle mortality rate (%YM), with the following formula:

$$YD = (\%SP + \%HP) \times IP \times \%YM \quad (5)$$

C. Loss due to abortion

Loss due to abortion (C) is calculated from the number of calves lost due to abortion (CA) multiplied by estimated selling price of calf per head (RpF), with the following formula:

$$C = CA \times RpF \quad (6)$$

Estimated number of calf lost due to abortion (CA) is obtained from the pregnancy rate of cow (%PR) multiplied by percentage of cow population (%CP), then multiplied by estimated number of infected cattle in the affected area (IP), then multiplied again by abortion rate due to FMD (%AR), with the following formula:

$$CA = \%PR \times \%CP \times IP \times \%AR \quad (7)$$

D. Loss due to decreased calf growth

Loss due to decreased calf growth (D) is calculated from the number of calves undergo growth decrease (CG) multiplied by percentage of compensation payment per head (%CP) estimated selling price of calf per head (RpF), with the following formula:

$$D = CG \times RpF \quad (8)$$

The number of calf undergo growth decrease (CG) is obtained from the percentage of male calf population (%MP) plus the percentage of female calf population (%FP) multiplied by estimated number of infected cattle in the affected area (IP) then multiplied by percentage of decreased calf growth (%DC), with the following formula:

$$CG = (\%MP + \%FP) \times IP \times \%DC \quad (9)$$

E. Culling Cost

Culling cost (E) is calculated from the estimated number of adult cattle being culled (CL) multiplied by culling and disposal cost per head (RpCL), with the following formula:

$$E = CL \times RpCL \quad (10)$$

Estimated number of adult cattle being culled (CL) is obtained from the percentage of bull population (%BP) plus the percentage of cow population (%CP) multiplied estimated number of infected cattle in the affected area (IP), then multiplied by estimated culling rate (%CR), with the following formula:

$$CL = (\%BP + \%CP) \times IP \times \%CR \quad (11)$$

F. Compensation cost

Compensation cost (E) is calculated from the percentage of bull population (%BP) multiplied by estimated number of infected cattle in the affected area (IP) multiplied by estimated selling price of bull per head (RpB), then multiplied by estimated compemsation payment per head (%CH), plus the percentage of cow population (%CP) multiplied by estimated number of infected cattle in the affected area (IP) multiplied by estimated selling price of cow per head (RpC), then multiplied by estimated compemsation payment per head (%CH), with the following formula:

$$E = (\%BP \times IP \times RpB \times \%CH) + (\%CP \times IP \times RpC \times \%CH) \quad (12)$$

G. Vaccination cost

Vaccination cost (G) is calculated from the estimated number of vaccinated adult and young cattle (VAY) multiplied by estimated vaccine cost per head (RpVC) plus estimated operational vaccination cost per head (RpOVC), plus the number of vaccinator required per month (VR) multiplied by the estimated vaccinator operational cost per person (RpVOP), with the following formula:

$$G = VAY \times (RpVC + RpOVC) + (VR \times RpVOP) \quad (13)$$

Estimated number of vaccinated adult and young cattle (VAY) is obtained from the percentage of bull population (%BP) plus the percentage of cow population (%CP) plus the percentage of steer population (%SP) plus the percentage of heifer population (%HP), then multiplied by total beef population in the affected area (TBP) and multiplied by estimated nmber percentage of vaccinated cattle (%TVC), with the following formula:

$$VAY = (\%BP + \%CP + \%SP + \%HP) \times TBP \times \%TVC \quad (14)$$

Estimated number of vaccinator required per month (VR) is calculated based on the ability of one personnel to conduct vaccination against 1,000 cows per month multiplied by time needed for control outbreak in months (TOM), with the following formula:

$$VR = VAY/1000 \times TOM \quad (15)$$

H. Cold chain and field officer training cost

Cold chain and field officer training cost (H) is calculated from estimated cold chain investment cost (RpICH) plus estimated number of field officer training required (NFT) multiplied by estimated cost for field officer training (RpFOT), with the following formula:

$$H = RpICH + (NFT \times RpFOT) \quad (16)$$

I. Surveillance cost

Surveillance cost (I) is calculated from the estimated number of investigation performed (SP) multiplied by estimated surveillance cost per investigation (RpSI) plus estimated surveillance operational cost per investigation (RpOSI) plus estimated sample delivery cost to reference laboratory (RpRL), with the following formula:

$$I = SP \times (RpSI + RpOSI) + RpRL \quad (17)$$

J. Movement restriction cost

Movement restriction cost (J) is calculated from beef cattle population in the affected area (TBP) multiplied by estimated border control cost per head (RpBCC) plus estimated quarantine disinfection cost per head (RpQDC), with the following formula:

$$J = TBP \times (RpBCC + RpQDC) \quad (18)$$

K. Outbreak control management cost

Outbreak control management cost (K) is calculated from number of villages in the affected area (VAA) multiplied by estimated control management cost per village (RpCMC), with the following formula:

$$K = VAA \times RpCMC \quad (19)$$

L. Information, Education and Communication (IEC) cost

Information, Education and Communication cost (L) is calculated from number of villages in the affected area (VAA) multiplied by estimated IEC cost per village (RpIEC), with the following formula:

$$L = TBP \times RpIEC \quad (20)$$

APPENDIX 4.

FMD Economic Impact (if an FMD outbreak occurs)

Name of infected area	Krucil subdistrict in Probolinggo District	3 districts in East Java province	2 provinces in Java island
Number of beef cattle in the affected area (TBP)	26,759	912,914	6,090,256
Number of villages in the affected area (VAA)	14	863	15,533

Population structure:	**Scenario 1**	**Scenario 2**	**Scenario 3**
Percentage of bull population (%BP)	11.0%	11.0%	11.0%
Percentage of cow population (%CP)	34.4%	34.4%	34.4%
Percentage of steer population (%SP)	14.3%	14.3%	14.3%
Percentage of heifer population (%HP)	18.0%	18.0%	18.0%
Percentage of male calf population (%MP)	11.1%	11.1%	11.1%
Percentage of female calf population (%FP)	11.2%	11.2%	11.2%

Selling price:			
Estimated selling price of bull per head (RpB)	Rp 14,700,000	Rp 14,700,000	Rp 14,700,000
Estimated selling price of cow per head (RpC)	Rp 11,025,000	Rp 11,025,000	Rp 11,025,000
Estimated selling price of young cattle per head (RpY)	Rp 7,000,000	Rp 7,000,000	Rp 7,000,000
Estimated selling price of calf per head (RpF)	Rp 5,000,000	Rp 5,000,000	Rp 5,000,000

	Scenario 1	**Scenario 2**	**Scenario 3**
Number of infected cattle (Ro= 2.0 initial outbreak) (IP)	1,006	55,488	201,951

DIRECT LOSSES

Visible losses:			
Estimated adult cattle mortality rate (%AM)	2%	2%	2%
Estimated young cattle mortality rate (%YM)	5%	5%	5%
Invisible losses			
Estimated abortion rate due to FMD (%AR)	10%	10%	10%
Estmated of decreased calf growth (%DC)	20%	20%	20%
Estimated number of bull deaths due to FMD (BD)	2	122	444
Estimated number of cow deaths due to FMD (CD)	7	382	1,389
Loss due to adult cattle deaths (A)	**Rp 108,841,152**	**Rp 6,003,357,696**	**Rp 21,849,482,592**
Estimated number of young cattle deaths due to FMD (YD)	16	896	3,262
Loss due to young cattle death (B)	**Rp 113,728,300**	**Rp 6,272,918,400**	**Rp 22,830,560,550**
Pregnancy rate of cow (%PR)	60%	60%	60%
Estimated number of calf lost due to abortion (CA)	21	1,145	4,168
Loss due to abortion (C)	**Rp 103,819,200**	**Rp 5,726,361,600**	**Rp 20,841,343,200**
Estimated number of calves with (CG)	45	2,475	9,007
Loss due to decreased calf growth (D)	**Rp 224,338,000**	**Rp 12,373,824,000**	**Rp 45,035,073,000**
TOTAL DIRECT LOSSES	**Rp 550,726,652**	**Rp 30,376,461,696**	**Rp 110,556,459,342**
	$ 42,364	**$ 2,336,651**	**$ 8,504,343**

INDIRECT LOSSES

Culling			
Culling rate (%CR)	60%	20%	20%
Estimated number of adult cattle being culled (CL)	274	5,038	18,337
Culling and disposal cost per head (RpCL)	Rp 500,000	Rp 500,000	Rp 500,000
Culling cost (E)	**Rp 137,017,200**	**Rp 2,519,155,200**	**Rp 9,168,575,400**
Compensation			
Estimated compensation payment per head (%CH)	70%	70%	70%
Compensation cost (F)	**Rp 3,809,440,320**	**Rp 210,117,519,360**	**Rp 764,731,890,720**
Vaccination			
Percentage of vaccinated cattle (%TVC)	100%	100%	100%
Estimated number of vaccinated adult & young cattle (VAY)	20,518	704,296	4,713,792
Vaccine cost per head (RpVC)	Rp 40,000	Rp 40,000	Rp 40,000
Vaccinatinator operational cost per person (RpOVC)	Rp 5,000	Rp 5,000	Rp 5,000
Time needed for outbreak control in months (TOM)	6	12	24
Number of vaccinator required (VR)	123	8,452	113,131
Vaccinator operational per person per month (RpVOP)	Rp 8,000,000	Rp 8,000,000	Rp 8,000,000
Vaccination cost (G)	**Rp 1,908,146,900**	**Rp 99,305,717,332**	**Rp 1,117,168,647,404**
Cold chain and field officer training			
Cost of cold chain investment (RpICH)	Rp 250,000,000	Rp 250,000,000	Rp 250,000,000
Number of field officer training (NFT)	1	4	8
Cost of field officer training (RpFOT)	Rp 75,000,000	Rp 75,000,000	Rp 75,000,000
Cost of cold chain and field officer training (H)	**Rp 325,000,000**	**Rp 550,000,000**	**Rp 850,000,000**
Surveillance			
Number of investigation performed (SP)	3	6	12
Surveillance cost per investigation (RpSI)	Rp 15,000,000	Rp 15,000,000	Rp 15,000,000
Surveillance operational cost per investigation (RpOSI)	Rp 30,000,000	Rp 30,000,000	Rp 30,000,000
Cost of sample delivery to reference laboratory (RpRL)	Rp 50,000,000	Rp 50,000,000	Rp 50,000,000
Surveillance cost (I)	**Rp 185,000,000**	**Rp 320,000,000**	**Rp 590,000,000**
Movement restriction			
Cost of border control per head (RpBCC)	Rp 75,000	Rp 75,000	Rp 75,000
Cost of quarantine desinfection per head (RpQDC)	Rp 2,500	Rp 2,500	Rp 2,500
Cost of cattle traffic restriction (J)	**Rp 2,073,822,500**	**Rp 70,750,835,000**	**Rp 471,994,840,000**
Outbreak control management			
Cost of outbreak control management per village (RpCMC)	Rp 600,000	Rp 600,000	Rp 600,000
Cost of outbreak control management (K)	**Rp 195,000,000**	**Rp 517,800,000**	**Rp 9,319,800,000**
Communication, Information and Education (IEC)			
IEC cost per village (RpIEC)	Rp 40,000	Rp 40,000	Rp 40,000
Cost of IEC (L)	**Rp 13,000,000**	**Rp 34,520,000**	**Rp 621,320,000**
TOTAL INDIRECT LOSSES	**Rp 8,646,426,920**	**Rp 384,115,546,892**	**Rp 2,374,445,073,524**
	$ 665,110	**$ 29,547,350**	**$ 182,649,621**
TOTAL LOSSES DURING OUTBREAK	**Rp 9,197,153,572**	**Rp 414,492,008,588**	**Rp 2,485,001,532,866**
	$ 707,473	**$ 31,884,001**	**$ 191,153,964**

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COST BENEFIT ANALYSIS of

Maintaining FMD Freedom Status in Indonesia