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Qualitative risk assessment and management

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Abbreviations

ASF	African swine fever
EDTA	Ethylenediamine tetra acetic acid
EFSA	European Food Safety Authority
ELISA	Enzyme-linked immunosorbent assay
EMC-AH	Emergency Management Centre for Animal Health (FAO)
FMD	foot-and-mouth disease
GMS	Greater Mekong Subregion
GTPV	goatpox virus
HPAI	highly pathogenic avian influenza
LSD	lumpy skin disease
LSDV	lumpy skin disease virus
OIE	World Organisation for Animal Health
PCR	polymerase chain reaction
SPP	sheeppox
SPPV	sheeppox virus

Summary

Lumpy skin disease (LSD) caused by the lumpy skin disease virus (LSDV) is a vector-borne disease of cattle and Asian water buffalo that causes substantial economic losses and requires technically sound and coordinated efforts for its prevention and control. It is on the OIE (World Organisation for Animal Health) list of notifiable diseases.

LSD was introduced into Bangladesh, China, and India, beginning from July 2019. In 2020 the disease then spread to other parts of China and India as well as Nepal and Bhutan. This document compiles the latest information available on the LSD situation in South, Southeast and East Asia and describes the complex bovine value chain in the region.

A qualitative risk assessment of the likelihood of introduction and/or spread of LSD in 23 countries in South, East and Southeast Asia covering the period October–December 2020 was conducted. Please note, this risk assessment takes into account information available up to 31 October 2020.

- Cambodia, Lao People's Democratic Republic, Myanmar, Thailand, and Viet Nam have been assessed at high risk of LSD introduction with moderate uncertainty due to the presence of LSDV in South Asia and China, the high number of susceptible cattle and buffalo, significant informal trade in cattle and buffalo and their products between these countries and LSD-affected countries, poor biosecurity in cattle/buffalo production systems and along the value chain, the moderate abundance of competent vectors during October–December, and the current absence of vaccination.
- Afghanistan and Mongolia have been assessed at moderate risk of LSD introduction with high uncertainty, and Pakistan with moderate uncertainty, due to the presence of LSD in South Asia and China, the high number or density of susceptible cattle and buffalo, the informal trade in cattle and buffalo and their products between these countries and LSD-affected countries, poor biosecurity in cattle/buffalo production systems and along the value chain, the very low (in Afghanistan and Mongolia), or low to moderate (in Pakistan) abundance of competent vectors during October–December, and the current absence of vaccination.
- Brunei Darussalam, Democratic People's Republic of Korea, Indonesia, Malaysia, the Philippines, Sri Lanka, and Timor-Leste have been assessed at low to moderate risk of LSD introduction with moderate uncertainty due to the absence of LSD in neighbouring countries and/or the remoteness of these countries, the lower density of susceptible cattle and buffalo, and/or major live cattle and buffalo imports mainly from Oceania, the small informal trade in cattle and buffalo and their products between these countries only or the (quasi)-absence of informal trade, poor biosecurity in cattle/buffalo production systems and along the value chain, the very low (for Democratic People's Republic of Korea) or moderate abundance of competent vectors during October–December, and the current absence of vaccination.

- Japan and the Republic of Korea have been assessed at very low risk of LSD introduction with moderate uncertainty due to the absence of LSD in immediate neighbouring countries and/or the remoteness of these countries, the smaller number of susceptible cattle and buffalo, live cattle and buffalo imports from LSD-free countries, the absence of informal imports of live cattle and buffalo and their products, moderate to high biosecurity in cattle/buffalo production systems and along the value chain, the very low to low abundance of competent vectors during October–December, and the current absence of vaccination.
- Singapore has been assessed at negligible risk of LSD introduction with low uncertainty.
- Among countries already affected, Bangladesh, India and Nepal have been assessed at high risk of LSD spread with low uncertainty, and moderate uncertainty for Bhutan and China, due to the widespread presence of LSD in parts of these countries (except Bhutan), the high number of susceptible cattle and buffalo, the significant informal trade in cattle and buffalo and their products within these countries, poor biosecurity in cattle/buffalo production systems and along the value chain, the very low to moderate abundance of competent vectors during October–December (depending on latitude and altitude), and the current absence of large-scale vaccination targeting susceptible livestock.

The economic impact of LSD on South, East and Southeast countries was estimated to be up to USD 1.45 billion in direct losses of livestock and production. The detection of an exotic disease may have severe trade implications for infected countries. Asian exports of live cattle and buffalo meat and meat products, dairy products and hides accounted for USD 5.5 billion in 2017. The cost effectiveness estimate in this paper demonstrates a strong economic justification for vaccination under any scenario, since direct vaccination costs are lower than estimated direct losses, even without considering potential additional indirect losses. Regional funding mechanisms and approaches to harmonize vaccination strategies should be explored.

This document provides an overview on LSD control approaches, including prevention. We discuss priority control methods including: 1) vaccination of susceptible herds with >80 percent coverage; 2) movement control of cattle and buffalo and quarantine; and 3) slaughter campaigns (where feasible according to country context) to prevent spread.

The preferable vaccines for LSD are homologous – based on the Neethling strain of LSDV and heterologous – based on goat pox virus (GTPV). Each batch of homologous and heterologous vaccines should be tested for quality and safety control. Countries need to decide which policy goal is realistic and feasible to devise national prevention and control strategies. In addition, a regional approach should ensure that individual national policy goals are compatible and harmonized control measures are implemented. It is important to note that maximum protection is achieved approximately three weeks post-vaccination.

Background

Lumpy skin disease (LSD) caused by the lumpy skin disease virus (LSDV) is an OIE notifiable, vector-borne disease of cattle and Asian water buffalo that causes substantial economic losses. Its name originates from the clinical presentation of the disease generally associated with the appearance of skin nodules that may cover the entire body of the animal during severe infection. While mortality rates in cattle are often low, the relatively high morbidity of LSD once introduced into naïve populations can lead to significant income losses for farmers brought about by decreased milk production, damaged hides, emaciation of animals, infertility and abortions. Subsequent trade bans or other movement restrictions in affected countries place economic strain on the cattle industry, severely impacting on all actors along the value chain.

Since the first observation of the disease in Zambia in 1929, LSD has spread progressively and extensively throughout Africa, the Middle East, Southeastern Europe, Central Asia, and more recently South Asia and China. Currently, the disease is endemic in several countries across Africa, parts of the Middle East (Iraq, Saudi Arabia, Syrian Arab Republic), and Turkey.

July 2019 marked the first known introduction of LSD into South Asia, with Bangladesh officially reporting an outbreak (OIE, 2020). In August 2019, the disease appeared in India (OIE, 2020; Sudhakar *et al.*, 2020) and western China, in the Xinjiang Uyghur Autonomous Region bordering Kazakhstan (Liu *et al.*, 2020). In June 2020 LSD was again observed in China. Outbreak reports from other provinces, namely Fujian (1), Jiangxi (2), Guangdong (1), Anhui (1), Zhejiang (1) and Taiwan Province of China (34) followed (OIE, 2020), indicating the continued and widespread presence of the disease. This is supported by announcements on designation of control zones and implementation of LSD control measures also in Guangxi Autonomous Region (Leye County, 2020; Tianlin County, 2020) and Yunnan Province (Shidian County, 2020). Although not yet officially reported to OIE, according to media reports LSD has spread to the southern part of India since January 2020.

In Bangladesh, LSD had spread to all divisions by December 2019 (Kamruzzaman, 2020) and despite lack of official reports, several LSD type disease events are mentioned in media articles suggesting the disease is present in the country and had likely reached the northern most districts by March 2020. This hypothesis is supported by an unpublished study in Bangladesh evidencing LSD gene fragments through polymerase chain reaction (PCR) assay in cattle samples collected between July 2019 and January 2020. However, these findings were not reported through official channels.

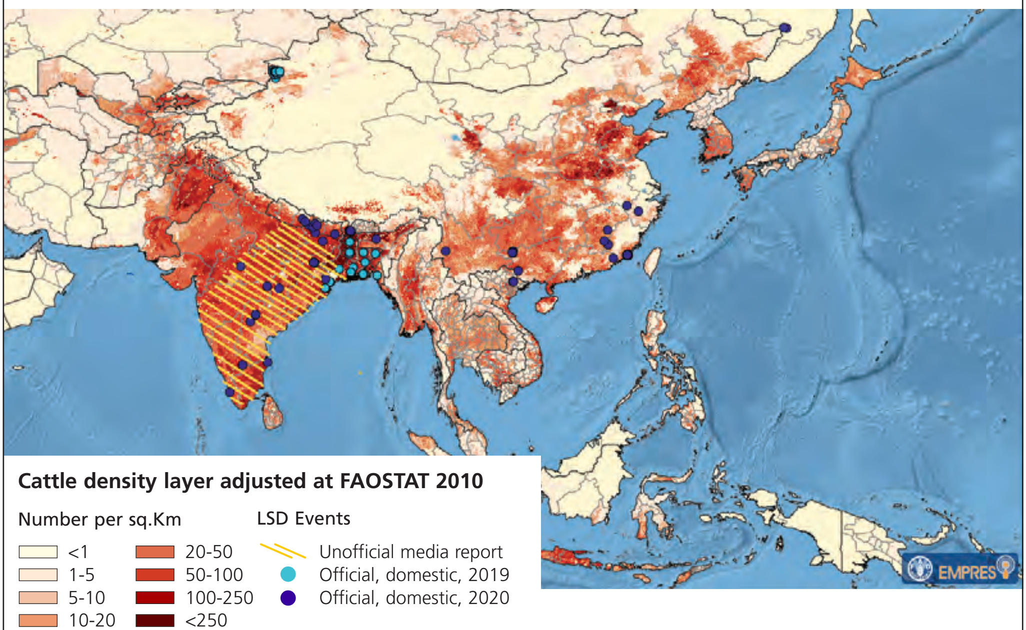
In June 2020 LSD affected Nepal for the first time with two outbreaks in the eastern part of the country (OIE, 2020). As of 18 September 2020, LSD continues to spread in the East and South Asia regions, with a number of outbreaks reported from seven provinces spanning South and East China, as well as reports from Nepal and India, and a recent confirmation of disease introduction in Bhutan (Table 1). The table includes only LSD outbreaks reported by official sources, including OIE notifications, official national reports and scientific publications. Outbreaks are displayed by onset date. Confirmed LSD outbreaks in Bangladesh (Kamruzzaman, 2020) with no precise numbers are indicated as 1*. Figure 1 depicts the outbreaks of LSD in South Asia and China in map format.

TABLE 1
Progression of LSD 2019-2020 in South Asia, and China up to 31 October 2020

	2019						2020										
Countries | *Month*	***7***	***8***	***9***	***10***	***11***	***12***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	**Total**
Bangladesh	3		1*	1*	1*	1*					1						8
Bhutan														4	1	3	8
China	5	14										5	24	16			64
India		8						1		1		1					11
Nepal												2	6	2			10
Total	8	22	1	1	1	1	0	1	0	1	1	8	30	22	1	3	101

Note: LSD outbreaks are included by onset date with information from reports up to 31 October 2020.

FIGURE 1
Incidents of LSD in South Asia and China between 2019 and 2020, from official and unofficial sources, mapped over cattle density up to 31 October 2020



Disclaimer: Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.
Source: FAO, 2020; using EMPRES-*i* database.

The recent LSD introductions in Asia are of concern as India, China and Bangladesh have some of the world's largest bovine populations. COVID-19 lockdown enforced in many Asian countries exacerbates already existing difficulties for veterinary services and laboratories trying to conduct timely outbreak investigation and disease diagnosis, which may result in delayed disease detection, reporting and implementation of control measures. There have been few risk assessments or risk models addressing introduction or spread of LSD in the past, these mainly targeting countries in Africa, Europe and Central Asia (Alemayehu, Zewde and Admassu, 2013; Allepuz, Casal and Beltrán-Alcrudo, 2019; Mercier *et al.*, 2017; Saegerman *et al.*, 2018).

A qualitative risk assessment was conducted on the likelihood of introduction and/or spread of LSD in 23 countries in South, East and Southeast Asia[1] to highlight countries at higher risk. Please note this risk assessment takes into account information available up to 31 October 2020. This document also compiles the latest information available on the LSD situation in South, Southeast and East Asia and describes the complex bovine value chains in the region.

It also assesses the socio-economic impact if the disease spreads in the region and discusses prevention and control approaches .

[1] Among the countries the qualitative risk assessment targeted are: Afghanistan, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China, Democratic People's Republic of Korea, India, Indonesia, Japan, Lao People's Democratic Republic, Malaysia, Mongolia, Myanmar, Nepal, Philippines, Republic of Korea, Singapore, Sri Lanka, Thailand, Timor-Leste, and Viet Nam.

Epidemiology of lumpy skin disease

Apart from foot-and-mouth disease (FMD) LSD is one of the economically most important viral diseases of cattle and Asian water buffaloes since rinderpest was eradicated globally. LSD typically reduces milk yield, causes severe emaciation, permanent damage to hides, several secondary complications, months-long chronic debility (Davies, 1991), and incurs movement or trade bans.

THE VIRUS

The LSDV belongs to the genus *Capripoxvirus* within the *Poxviridae* family and shares high antigenic similarities with the sheeppox virus (SPPV) and the goatpox virus (GTPV), two other members of this genus. While SPPV and GTPV serologically crossreact with LSDV, they do not cause disease in species other than their respective host.

THE HOST

LSD is an infectious disease of cattle and Asian water buffalo (*Bubalus bubalis*). Breeds of *Bos taurus* with high milk production are more susceptible than African/Asian indigenous cattle

BOX A

Survival and inactivation of lumpy skin disease virus

Lumpy skin disease virus (LSDV) is a large, double-stranded DNA virus. It is stable in the environment and may remain viable up to three months in dry scabs on skin, at least six months in dirty, shaded pens and infected tissue culture fluid stored at 4°C. Infected animals shed scabs from skin lesions and inside the scabs the virus may remain infectious for several months. LSDV survives in necrotic skin nodules for at least 39 days even dried out prior to sequestration and in air-dried hides at room temperature for at least 18 days. There are no studies published that identify how long it takes for LSDV to lose infectivity in different environments.

LSDV survives well within the pH range 6.3-8.3. It is highly susceptible to sunlight, high alkaline or acid pH; can be inactivated at 55° C for 2 h, 60° C for 1 h or 65° C for 30 min, or by most detergents such as sodium dodecyl sulphate and detergents containing lipid solvents; (2 percent) Virkon®, (2–3 percent) sodium hypochlorite, (20 percent) chloroform, (2 percent) phenol in 15 min, (1 percent) formalin, (1:33) iodine compounds, and (0.5 percent) quaternary ammonium compounds.

Sources: Weiss, 1968; EFSA, 2015; Tuppurainen, Alexandrov and Beltrán-Alcrudo, 2017; OIE, 2017; DEFRA, Scottish Government and Welsh Government, 2018; Tuppurainen, Babiuk and Klement, 2018

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The clinical examination and symptomatic treatment of LSD during the 2016/2017 outbreak in Albania.

(*Bos indicus*). The morbidity varies from 2 to 45 percent and is lower in Asian water buffaloes. Mortality in cattle is usually less than 10 percent, but can be higher in certain breeds, age groups or in high milk producing cows (Tuppurainen, Alexandrov and Beltrán-Alcrudo, 2017).

In wildlife, clinical LSD has been reported in an Arabian oryx (*Oryx leucoryx*), in springbok (*Antidorcas marsupialis*), and experimental infection could produce clinical signs in impala (*Aepyceros melampus*) and giraffe (*Giraffa camelopardalis*) (Tuppurainen, Babiuk and Klement, 2018) and Thomson's gazelle (*Eudorcas thomsonii*) (Davies, 1991). Blue wildebeest (*Connochaetes taurinus*), black wildebeest (*Connochaetes gnou*), springbok, impala and eland (*Taurotragus oryx*) have tested positive for LSD antibodies in South Africa (Barnard, 1997) as have African buffalo (*Syncerus caffer*) in Kenya (Davies, 1982) and South Africa (Fagbo, Coetzer and Venter, 2014). However, no LSD case has ever been detected in these species in their natural habitat and the possible role of wild ruminants in LSD epide-

BOX B

Wild species of genus *Bos* and *Bubalus* under Convention on International Trade in Endangered Species in Asia

Gaur (*Bos gaurus*)
Wild yak (*Bos mutus*)
Wild water buffalo (*Bubalus arnee*)
Lowland anoa (*Bubalus depressicornis*)
Tamaraw (*Bubalus mindorensis*)
Mountain anoa (*Bubalus quarlesi*)

miology is still unknown (Davies, 1991; Tuppurainen, Babiuk and Klement, 2018). Asia has unique wild species of genus *Bos* and *Bubalus*, some of which are listed by CITES (CITES, 2020). Their susceptibility to LSDV is currently unknown.

NATURAL HISTORY OF THE DISEASE

The characteristic nodular skin lesions appear on head, neck, chest, abdomen, perineum, genitalia, udder and limbs. The centre of the lesion often ulcerates and with time a scab forms on top (Tuppurainen, Alexandrov and Beltrán-Alcrudo, 2017).

The incubation period in naturally infected animals may be up to 28 days. Clinical signs in cattle, besides the skin nodules, include lachrymation, nasal discharge, high fever (>40.5°C), appetite loss, enlarged subscapular and prefemoral lymph nodes, sharp drop in milk yield, necrotic plaques in oral and nasal mucous membranes and reduced fertility.

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Local Terai cow in Morang, Nepal with small skin nodules all over the body; LSD confirmed by PCR.

© GANESH, K.C. / VETERINARY LABORATORY, POKHARA

A buffalo in Pokhara Metropolitan, Gandaki Province, Nepal with small skin nodules all over the body; confirmed by PCR.

Buffaloes may also show skin lesions (Elhaig, Selim and Mahmoud, 2017).

Once scabs are found, the virus has probably been circulating within the herd for at least 3–4 weeks. LSDV is present in the skin lesions and the scabs, blood, nasal, oral and ocular secretions, semen, and sometimes in the skin of cattle without visible clinical signs. A study showed that only half of experimentally infected cattle develop skin lesions (Tuppurainen, Babiuk and Klement, 2018). Non-clinical but viraemic animals are common and may be a source of infection through vectors such as mosquitos that feed directly on small blood vessels (Tuppurainen, Alexandrov and Beltrán-Alcrudo, 2017) or spread the disease when moved by foot or in a vehicle. Infected animals shed the virus through oral and nasal secretions which may contaminate common feeding and water troughs. Experimental studies confirmed virus transmission through artificial insemination (Annandale *et al.*, 2013) and the negative impact of LSDV contaminated semen on *in vitro* fertilization (Annandale, 2020). The European Food Safety Authority has summarized the period of LSDV detection in different matrices (EFSA, 2015).

Animals are usually treated using supportive therapy of local wounds to prevent fly infestation and secondary infections. Systemic antibiotics may be given for more serious cases of disease. The animals may become debilitated for up to six months, with a drop in milk production, caused by loss of feed intake due to mouth lesions. Mobility and fertility can also be impacted. Under pastoral conditions, animals may become dehydrated and starve to death. Secondary bacterial infections of skin lesions are common and pneumonia may be a complication in animals with mouth lesions.

TRANSMISSION

LSD is transmitted primarily mechanically by blood-feeding insects. Other routes of spread are iatrogenic, through direct or indirect contact and artificial insemination. Various flying and non-flying blood-feeding insects can transmit LSDV mechanically and play a major role in within-herd as well as between-herd transmission. Potential arthropod vectors vary by region (Coetzer *et al.*, 2018). The seasonal pattern of LSD in Africa, as well as in temperate

BOX C

Lumpy skin disease vectors

LSDV can be transmitted by various blood-feeding arthropods but is not known to replicate in vectors. Therefore, transmission is mechanical but not biological in nature. Potential vectors studied to date:

Mosquitos: *Aedes aegypti, Anopheles stephensi, Culex quinquefasciatus*

Flies: *Stomoxys calcitrans, Haematobia irritans, Prostomoxys sp., Haematopota spp., Biomyia fasciata*

Midges: *Culicoides nubeculosus*

Ticks: *Rhipicephalus appendiculatus, Rhipicephalus decoloratus, Amblyomma hebraeum*

Sources: Kitching and Mellor, 1986; Chihota *et al.*, 2001; Wamwayi, 2004; Tuppurainen, Babiuk and Klement, 2018; Sohier *et al.*, 2019 zones supports an important role of vector involvement in LSD epidemiology. In countries with warm winters there is less seasonality in vector transmission. As LSD spreads into new geographic and climatic regions, different vectors may become more dominant in transmission; changes in seasonality should be anticipated. While such flying vectors spread the virus at relatively slow speeds, e.g. 7.3 km/week in the Balkans (Mercier *et al.*, 2017), transporting or walking animals play an important role in long-distance spread. Ticks may play a role in maintaining LSDV during dry or cold seasons. Although ticks do not move much, tick-infested live animals on vehicles can transmit LSDV over long distances. Some birds may also act as vectors for LSD transmission in Africa.

Each vector has a preferred environmental temperature, humidity and type of vegetation. In Africa, the Middle East and Europe, there is seasonality in LSD incidence due to vectors being less active during the dry season or cold winters. However, there may be no vector-free season in some Asian countries given prevalent climatic conditions.

Drivers of LSD introduction and spread

LIVE CATTLE AND BUFFALO TRADE

Asia's unprecedented economic growth and urbanization during the last two decades have led to significant changes in consumption patterns and, as a result, the demand for cattle and buffalo products (e.g. beef, carabeef[2] or milk) has increased (OECD/FAO, 2018). Countries not able to meet the demand rely heavily on imports of live animals or their products from within the Asia region, or beyond. Asia is a major pillar for cattle and buffalo production globally, being home to more than 650 million head of cattle and buffaloes, accounting for about 39 percent of the global stock. Most are concentrated in South, Southeast, and East Asia. India has the largest number with nearly 300 million head, followed, albeit distantly, by China (approximately 90 million), and Pakistan (approximately 85 million) as described in Table 2 (FAOSTAT, 2020). India is also the second largest beef exporter worldwide, after Brazil, with 527 tonnes carcass weight equivalent exported in 2018 (Zia *et al.*, 2019).

TABLE 2
Top 10 countries with the largest cattle and buffalo inventory in South, East, and Southeast Asia

Country	Stock of cattle and buffalo in head	% of cattle/buffalo
India	298 615 805 (*)	62/38
China	90 536 564 (*)	70/30
Pakistan	84 932 000 (O)	54/46
Bangladesh	25 571 000 (O)	94/6
Myanmar	21 208 395 (*)	82/18
Indonesia	17 327 223 (O)	95/5
Nepal	12 654 125 (O)	58/42
Viet Nam	8 228 012 (O)	70/30
Thailand	5 914 926 (*)	79/21
Philippines	5 436 592 (O)	47/53

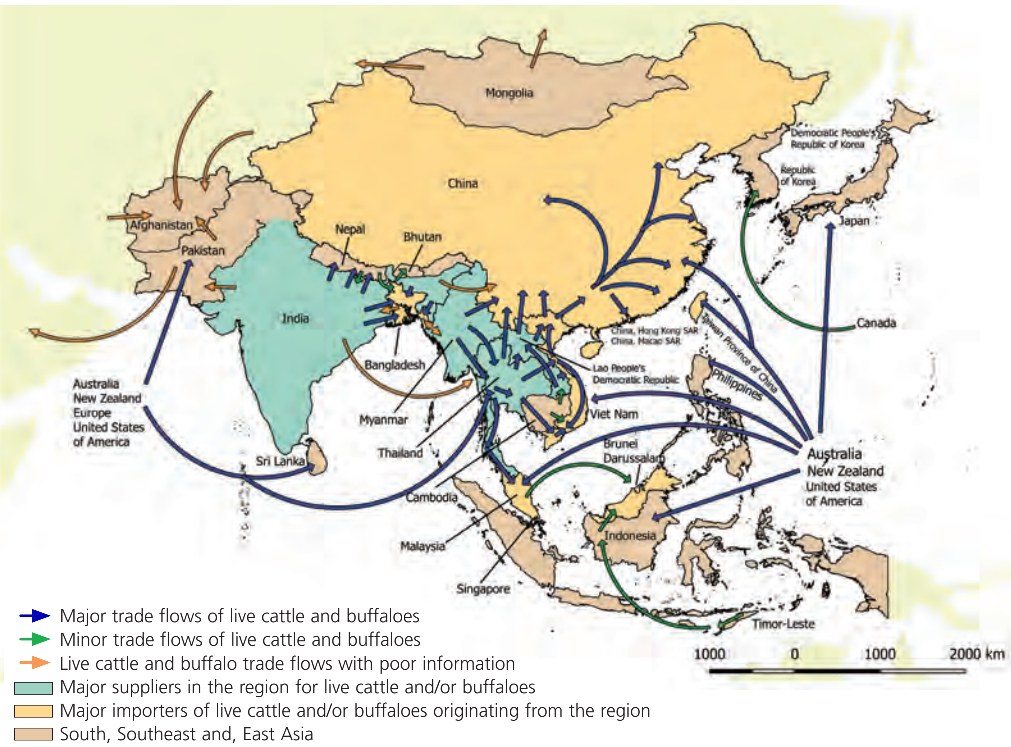
Figures are based on either official data (O) or imputation methodology (*).
Source: FAOSTAT, 2020

[2] In India, only frozen boneless buffalo meat, so called carabeef, is authorized for production and export.

Drivers influencing trade flows between countries are multiple, including economic growth, animal production trends, consumption patterns, political relationships, geographical proximity or obstacles (e.g. mountains or sea), seasonal factors (e.g. festivals, monsoon), disparities in commodity prices between countries, or the introduction/emergence of animal diseases. In the past, animal diseases (e.g. African swine fever – ASF or highly pathogenic avian influenza – HPAI) have severely affected livestock markets due to animal mortality, production losses, shift in consumption patterns, or trade bans.

The cattle and buffalo trade in Asia is very complex, involving a significant number of actors, animals, means of transport, and a plethora of trade routes that constitute a challenge for movement control or veterinary checks (Figure 2). The Belt and Road Initiative launched by the Government of China in 2013 aims at expanding infrastructure network along the historic Silk Road (terrestrial and maritime). It supports the development of new

FIGURE 2
Formal and informal trade flows of live cattle and buffalo across South, East and Southeast Asia



Disclaimer: Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.
Note: This map does not differentiate between normal and informal trade. Given the rapid evolution of trade in Asia, it may not reflect recent changes in trade flows.
Source: United Nations Geospatial Information Section (map boundary). Information retrieved from various sources, including a questionnaire sent to FAO Country and Regional Offices as well as United Nations databases (FAOSTAT, 2020; United Nations Statistic Division, 2020) and national value chain reports (Asia Beef Network, 2020; Asian Development Bank, 2015; Smith *et al.*, 2015; World Bank, 2007 and 2014).

trade routes from East Asia to the Middle East and Eurasia, facilitating trade flows including the live animal trade (Ministry of Foreign Affairs of the People's Republic of China, 2013). While some official trade agreements are in place between countries, semi-informal and informal trading practices are prominent in various parts of Asia, making it difficult to estimate their true extent. Most of the live animal trade occurs between neighbouring countries, however animals can sometimes travel thousands of kilometres and cross several countries (i.e. transit countries), as observed for instance with live cattle or buffaloes from Myanmar exported by truck to their final destination, Viet Nam, through Thailand, Cambodia, and the Lao People's Democratic Republic. LSD spread over long distances is strongly associated with the movement of infected animals and potential transport of infected vectors that further transmit the virus to naïve cattle (Tuppurainen, Alexandrov and Beltrán-Alcrudo, 2017). Countries in Asia have progressively increased the number of control points and quarantine facilities at the borders due to the presence of other cattle diseases in the region (e.g. FMD). Nevertheless, the potentially long incubation period for LSD in naturally infected animals (up to five weeks) and the presence of non-clinical animals may facilitate cross-border spread when trading infected animals that are apparently healthy but incubating the virus (Spickler and Roth, 2008).

The long porous borders between India, Nepal and Bangladesh allow for a significant amount of bilateral and informal animal trade, including cattle and buffaloes. This may have favoured the spread of LSD in July–August 2019 between Bangladesh and India. According to a value chain study, Bangladesh has no formal cross-border trade with India (FAO, 2013a). However, given the gap between supply and demand for animal protein in Bangladesh and disparities in livestock prices with India, unofficial imports of livestock including cattle and buffaloes to meet animal protein demand have been observed (FAO, 2013a). Likewise, the introduction of LSD in Nepal in June 2020 was likely due to the continuous flow of informal cross-border movements of cattle from India to districts of eastern Nepal (particularly those bordering Bihar State in India), usually by foot, given there are no official records of live cattle or buffalo imports from India in the fiscal year 2019 (FAO, 2013b, 2014; FAO Nepal, personal communication, 2020).

Official imports of live cattle and buffaloes from other Asian countries to Myanmar are limited to occasional trade in high genetic value cattle breeds (FAO Myanmar, 2020 - personal communication). Informal trade with India and Bangladesh may occur but no specific value chain studies document its existence or extent. Extraordinary movements have been recorded in the past with live cattle travelling by boat from India and Bangladesh to Mawlamyine Port in Myanmar and further transit through Thailand and the Lao People's Democratic Republic to their final destination in China (Smith *et al.*, 2015). Myanmar is an exporter and a major supplier for the Greater Mekong Subregion (GMS). This is partly due to significant cattle and buffalo production accompanied by an extremely low level of beef consumption per capita. The price difference between cattle produced inside and outside Myanmar has led to substantial informal trade in live cattle and buffaloes between Myanmar and its neighbours, including China, Malaysia, Thailand and Viet Nam (Myint, Sein Sein and Khin Nyein, 2018; Si *et al.*, 2018). In 2017, a semi-informal trade agreement permitted live cattle exports from Myanmar to China. This trade has increased since its implementation with 186 916 cattle officially exported to China in 2019 (FAO Myanmar, personal communication, 2020).

Thailand is a major supplier of animals and also sources live cattle and buffaloes from Myanmar, India, Bangladesh and Malaysia. Animals sourced from outside Thailand are either fattened, slaughtered and sold locally for domestic consumption, sent to regional markets for further distribution in the Lao People's Democratic Republic, Cambodia, or transit through Thailand to reach Viet Nam or China via Cambodia or the Lao People's Democratic Republic (Ross, 2015; Smith *et al.*, 2015). In 2014, about 58 000 head of large ruminants transited from Thailand to China using Northwestern Province routes of the Lao People's Democratic Republic whilst from October 2014 to June 2015, nearly 32 000 head originating from Thailand reached Viet Nam through Khammouan Province (Smith *et al.*, 2015). Estimates for Lao People's Democratic Republic exports suggest about 100 000 cattle and buffalo head per year are destined for China and Viet Nam (FAO Lao People's Democratic Republic, personal communication, 2020). Cambodia is also an exporter – to a lesser extent – of local cattle and buffaloes. Most of the trade occurs informally with southern Lao People's Democratic Republic and Viet Nam (Smith *et al.*, 2015), where growing demand for meat has resulted in increased Cambodian exports. The recent expansion of Australia and New Zealand cattle and buffalo exports into new markets within Southeast Asia (e.g. Viet Nam) has presented strong competition to other countries in the region (Asia Beef Network, 2020; FAO, personal communications, 2020).

Outside the GMS, countries that are physically isolated, i.e. islands, peninsulas, or those surrounded by mountains, may have more control over informal cross-border trade, often through strict regulation at the port of entry (e.g. Bhutan, Japan, the Republic of Korea, or Singapore). On the other hand, island countries in South or Southeast Asia have developed significant official trade with Oceania, in particular Australia and New Zealand. For instance, Indonesia, with about 17 million cattle, imports almost all its live cattle (essentially feeder cattle) from Australia (FAOSTAT, 2020). Other countries including Brunei Darussalam, Timor-Leste, Philippines, or Sri Lanka do not have the capacity to maintain a cattle herd large enough to meet the local demand for meat – partly due to limited space and/or insufficient feed. Hence they officially import cattle and buffalo meat (chilled or frozen), mostly from Oceania and India (carabeef) (FAOSTAT, 2020). Formal or informal trade in live cattle and buffalo is still occurring and documented in the islands of Southeast Asia, albeit to a lesser extent than GMS. Informal movements of cattle were recorded from Timor-Leste to Indonesia (estimates between 5 000 and 10 000 head a year), with some even destined for Brunei Darussalam or Malaysia (Asia Beef Network, 2020).

Bordering northern China, the Democratic People's Republic of Korea has a relatively small cattle inventory (less than 600 000 head) and imports very small volumes of beef from China, whilst Mongolia produces excess ruminant meat each year and exports beef, sheep and goat meat to among others the Russian Federation, China, Japan, Republic of Korea, Iran, Kazakhstan and Viet Nam (CAMS, 2020; FAOSTAT, 2020; Ministry of Agriculture of the Democratic People's Republic of Korea, personal communication, 2020; SDC, 2015). China has imposed unilateral official trade regulations on imports from Mongolia partly due to the presence of high impact animal diseases in the past (e.g. FMD or peste des petits ruminants). Informal cross-border trade occurs between China and Mongolia, however the volumes and products involved are poorly documented. Concerning Pakistan and Afghanistan, there are few data available on the live cattle and buffalo trade which may not reflect the current situation. Afghanistan imported livestock and livestock products from Pakistan, India, Iran and the United Arab Emirates, but there are no precise data on the species and volumes available (World Bank, 2014).

TRADE IN CATTLE AND BUFFALO PRODUCTS

The increasing demand for cattle and buffalo products including beef, carabeef, offal, milk, and indirectly hides led to a rapid expansion of the trade in Asia, sometimes at the expense of controls, food safety and biosecurity. Import regulations for livestock, carcasses, hides, skins and semen are applied in countries where LSD is not present (OIE, 2019a).

Hides, meat, and milk from cattle and buffaloes constitute a relatively low risk for LSD spread as compared to the live trade in infected cattle or buffalo. Animals infected with LSD usually present with multiple and visible nodular lesions at slaughter, thus damaged hides or carcasses are likely to be discarded. So far, no study has evidenced the survival potential of the virus in meat (e.g. chilled, frozen), however it was shown that LSDV is inconsistently present in organs of experimentally infected cattle, albeit in significantly lower titres compared to skin lesions (ANSES, 2017). In addition, part of the cattle and buffalo meat is processed at high temperatures (e.g. boiled or thoroughly cooked) that results in virus inactivation (Babiuk, 2018). Hides with skin lesions (e.g. nodules, crusts, holes, or discolourations) can yield very high titres of LSDV by PCR (Babiuk *et al.*, 2008; Weiss, 1968), but most of the time are removed from the value chain as mentioned. It has yet to be demonstrated if tanning (soaking, salting, and basic/acid agent treatments) inactivates LSDV in undamaged hides from infected animals. When not treated, contaminated hides may harbour live virus for a fairly long time, at least 18 days in air-dried hides and up to three months in dry scabs on skin (EFSA, 2015). Nevertheless, the likelihood of susceptible hosts coming into contact with infected hides is low.

In the past, LSDV has only been detected by PCR in milk at apparently low titres and no virus isolation could be performed (ANSES, 2017), therefore it is not possible to confirm the presence of viable and infectious virus in milk. A large portion of the milk produced in Asia is processed after collection either through pasteurization or by boiling and drying to generate milk powder. This will ensure the inactivation of LSDV in the milk (inactivation in 2 h at 56°C and 30 min at 65°C) (Spickler and Roth, 2008).

Most importantly, even with trade in contaminated meat (fresh, chilled, or frozen), fresh milk, or hides, the final purpose of such products is human consumption or handcrafts (e.g. tanneries for leather production), susceptible hosts are unlikely to come into contact with these contaminated products. Also, insect vectors involved in the transmission of LSDV are unlikely to be attracted or to feed on animal products. Non-blood sucking flies like houseflies (*Musca domestica*) do feed on animal products as well as live cattle, but play a very minor role, if any, in the transmission of LSDV to naïve cattle.

Poor biosecurity along the value chain favours accumulation, survival and spread of pathogens in the environment. LSDV is very stable and may survive over long periods, in particular in dry, cold conditions (Tuppurainen, Alexandrov and Beltrán-Alcrudo, 2017). Materials and vehicles transporting contaminated hides, carcasses, meat, offal, or milk could potentially act as fomites for LSDV if not cleaned and disinfected regularly. Significant trade flows in cattle and buffalo products also occur informally, generally with more risky practices employed as compared to official trade.

Bull semen is a particular case as the supply chain differs from that of other animal products. In laboratory settings, LSD could be transmitted to heifers by artificial insemination with infected bull semen (Annandale *et al.*, 2014). Viral nucleic acid of LSDV was detected by PCR in semen from experimentally infected bulls up to 159 days (Irons, Tuppurainen and Venter, 2005). Common semen processing methods were not able to eliminate LSDV from cryopreserved semen collected from experimentally infected bulls (Annandale, 2020). Many countries in Asia import and use frozen semen originating from countries or regions currently free of LSD (e.g. United States of America, Australia, Europe, or Thailand). Bull semen imported from breeds with higher genetic value is strictly controlled through a traceability system (semen identification, animal health certificates, imports authorization). In countries affected by LSD, using semen from local bulls may be a high risk practice, in particular involving infected but non-clinical bulls. Artificial insemination (and by extension, natural mating) of cattle and buffaloes is a risk factor for the spread of LSD amongst farms.

Risk assessment and economic impact

QUALITATIVE RISK ASSESSMENT

A qualitative risk assessment was conducted to assess the likelihood of introduction and/or spread of LSD in targeted countries in Asia.[3] In countries already affected by LSD, the assessment only considers the likelihood of spread. The risk assessment covers October–December 2020, takes into account information available up to 31 October 2020 and was based on the major risk pathways outlined in Figure 3.

Five levels were used to determine qualitatively the likelihood of introduction and/or spread, from highest to lowest as follows: high (highly likely to occur); moderate (potential to occur); low (unlikely to occur); very low (very unlikely to occur); and negligible (extremely unlikely to occur).

The assessment considers the level of uncertainty when interpreting the available data, based on data quality and quantity. Definition of uncertainty levels used are:

- high uncertainty: lack of data, limited data, or lack of conclusive data; weak correlation or crude speculation;
- medium uncertainty: small sample data set(s), fair correlation/good fit; reliable method;
- low uncertainty: large sample data set(s); known fact, event known to occur, or exact measure.

A questionnaire addressed LSD risk factors including a cattle/buffalo inventory, formal and informal trade volumes and routes of live cattle/buffalo and their products (e.g. meat, milk, hides), vector presence, vaccine availability, vaccination preparedness, emergency response plan, veterinary services capacity, animal control and quarantine at borders, cattle/buffalo production systems and biosecurity. The questionnaire was sent in mid-July 2020 to FAO Country and Regional Offices. Eleven completed questionnaires out of 23 countries were received from FAO Country Offices: Bhutan, Cambodia, Democratic People's Republic of Korea, Lao People's Democratic Republic, Malaysia, Myanmar, Nepal, Republic of Korea, Sri Lanka, Thailand, and Viet Nam. Additional information on risk factors for each target country was retrieved from various sources including United Nations databases (FAOSTAT, 2020; United Nations Statistics Division, 2020), national value chain reports, scientific publications and unpublished reports.

Annex 1 contains a table compiling major risk factors by country used for the qualitative risk assessment.

The section below considers evidence about hazard identification and drivers described earlier as well as additional data from questionnaires and literature searches.

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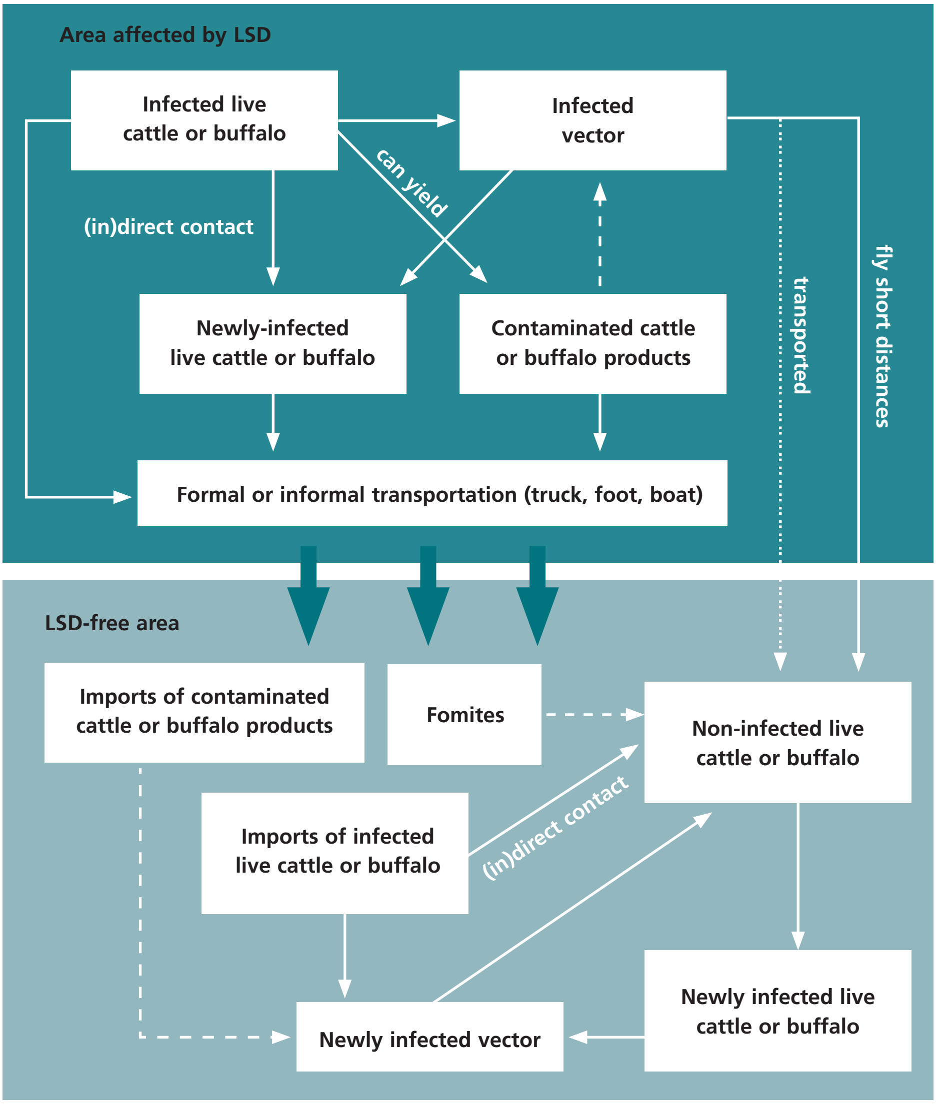
[3] The countries targeted include Afghanistan, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China, Democratic People's Republic of Korea, India, Indonesia, Japan, Lao People's Democratic Republic, Malaysia, Mongolia, Myanmar, Nepal, Philippines, Republic of Korea, Singapore, Sri Lanka, Thailand, Timor-Leste and Viet Nam.

FIGURE 3
Risk pathways for LSD introduction and spread



Note: Figure 3 depicts major risk pathways for LSD introduction from an affected to an unaffected area. Long lines of dashes reflect potential but likely minor pathways of LSD spread or transmission. The lines of short dashes represent the transport of infected vectors. Cattle or buffalo products include carcasses, meat, milk, hides, skins, and offal. Vectors include all competent blood-sucking arthropods for LSD spread which vary by region.
Source: Authors.

- The likelihood of introducing LSD is considered to be:
  - **High (i.e. highly likely to occur) with moderate uncertainty** for Cambodia, Lao People's Democratic Republic, Myanmar, Thailand, and Viet Nam. This is due to the presence of LSD in South Asia and China, the high number of susceptible cattle

and buffalo, significant informal trade in cattle and buffaloes and their products between these countries and LSD-affected countries, poor biosecurity in cattle/buffalo production systems and along the value chain, the moderate abundance of competent vectors during October–December and the current absence of vaccination. Depending on national capacities in early detection, farmer awareness and ability to recognize LSD and incentives in reporting, the disease may remain undetected or unreported for some time in these countries and spread freely once introduced. The volume of informal imports of live cattle and buffaloes originating from LSD-affected countries (mostly India and Bangladesh) into Myanmar and Thailand is not well documented and based on value chain studies conducted five years ago. This may have changed more recently.

- **Moderate (i.e. potentially occurring)** for Pakistan with moderate uncertainty, and for Afghanistan and Mongolia with high uncertainty. This is due to the presence of LSD in South Asia and China, a high or sufficient number or density of susceptible cattle and buffalo, informal trade in cattle and buffaloes and their products between these countries and LSD-affected countries, poor biosecurity in cattle/buffalo production systems and along the value chain, the very low (for Afghanistan and Mongolia), or low to moderate (for Pakistan) presence of competent vectors during October–December (these countries have generally rougher terrains – steppes and high plateau – and an unsuitable climate for mosquitoes), and the current absence of vaccination. The true extent of LSD spread in affected neighbouring countries that reported the disease officially (China, India and the Russian Federation) and in other countries in Western or Central Asia where LSD was reported officially or in the media in 2019 (Iran, Kazakhstan, Kyrgyzstan and Uzbekistan) is largely unknown. The volume of cross-border formal or informal imports of live cattle and buffaloes into Pakistan from LSD-affected countries is considered moderate, while not well documented for Afghanistan and Mongolia.
- **Low to Moderate** for Brunei Darussalam, Democratic People's Republic of Korea, Indonesia, Malaysia, Philippines, Sri Lanka, and Timor-Leste with moderate uncertainty. This is due to the absence of LSD in neighbouring countries (Brunei Darussalam, Indonesia, Malaysia, Philippines, Timor-Leste) and/or the remoteness of these countries (islands, peninsulas, or countries with short borders). It is also due to lower density of susceptible cattle and buffalo (except Java island in Indonesia, Philippines and Timor-Leste), major live cattle and buffalo imports from Oceania (apart from the Democratic People's Republic of Korea), little informal trade in cattle and buffalo and their products between these countries only or the quasi or total absence of informal trade (the Democratic People's Republic of Korea and Sri Lanka). Other factors include poor biosecurity in cattle/buffalo production systems and along the value chain, the very low (for the Democratic People's Republic of Korea) or moderate presence of competent vectors during October–December and the current absence of vaccination. The true extent of LSD spread in Asia is largely unknown. The origin and volume of informal imports of live cattle and buffaloes are not very well documented.

- **Very low (i.e. unlikely to occur) with moderate uncertainty** for Japan and the Republic of Korea, due to the absence of LSD in their immediate neighbouring countries and/or the remoteness of these countries, the smaller number of susceptible cattle and buffalo, live cattle and buffalo imports from LSD-free countries, the absence of informal imports of live cattle and buffalo and their products, moderate to high biosecurity in cattle/buffalo production systems and along the value chain, the very low to low abundance of competent vectors during October–December and the current absence of vaccination. The true extent of LSD spread in Asia is largely unknown.
- **Negligible (i.e. extremely unlikely to occur) with low uncertainty** for Singapore, due to the absence of LSD in bordering countries, the presence of a negligible number of susceptible cattle and buffalo (179 head in 2018), cattle and buffalo product imports from mostly LSD-free countries only, the absence of informal imports of live cattle and buffalo and their products.

- The likelihood of spread of LSD within already affected countries is considered to be:
  - **High with low uncertainty** for Bangladesh, India, and Nepal and moderate uncertainty for Bhutan and China, due to the extensive spread of LSD in parts of these countries, the high number of susceptible cattle and buffalo, the significant informal trade in cattle and buffalo and their products within these countries, poor biosecurity in cattle/buffalo production systems and along the value chain, the very low to moderate presence of competent vectors in October–December (depending on both latitude and altitude), and the absence of massive vaccination of susceptible livestock. LSD is highly likely to spread to high density cattle/buffalo areas in these countries (based on Gridded Livestock of the World 3, 2010), i.e. throughout Bangladesh, Bhutan, India, Nepal, and particularly South, Southeast, East, and Northeast China. Furthermore, the movement restrictions from COVID-19 pandemic mitigation measures hamper prompt laboratory diagnosis, outbreak investigation and control and prevention measures.

ECONOMIC IMPACT OF LSD IN ASIA

Asian cattle and buffalo account for more than 30 percent and 97 percent of the global population, respectively (FAOSTAT, 2020) and these animals play an important role in the socio-economic fabric of Asia. They are not only a source of income and food but also represent an accessible means to deposit savings and as a source of draught power. Such services help smallholders to overcome poverty hurdles, especially in poor settings where financial services and agricultural mechanization have not yet penetrated. Some communities value cattle and buffaloes highly for their role in social, cultural and religious traditions.

Knowing the economic impact of a disease can help decide on the most cost-effective disease control approach. Economically, Asia accounts for 31 percent and 98 percent of global cow and buffalo milk production respectively and 29 percent of the cattle slaughtered globally for meat production (FAOSTAT, 2020). LSD can inflict substantial direct losses through mortality, reduced milk production, damaged hides, poor growth, reduced draught power capacity and reproductive problems associated with abortions, infertility and lack of semen for artificial insemination. Vaccination costs, trade and other indirect revenue losses are directly proportional to the extent of LSD spread.

We used the parameters from Middle East countries to estimate likely losses from LSD in Asia. The rationale for using them is that, similar to Asia, cattle in the Middle East had an immunologically naïve status for LSD at the time of the initial incursion, in contrast to Africa where the disease has long been endemic. Reported LSD outbreaks affected on average 10.5 percent of cattle in the Middle East. Based on outbreak reports from 2012 to 2016 EMPRES-i and data from LSD publications for Middle East countries, clinical signs were observed in 18.5 percent and 2.9 percent of affected cattle and buffalo populations, respectively (FAO, 2020; Abutarbush, 2014; Tageldin *et al.*, 2014; Abutarbush *et al.*, 2015; Al-Salihi and Hassan, 2015) .

We constructed two scenarios using the median and mean percentage of cattle population affected by LSD in Middle East countries according to outbreak reports from 2012 to 2016. Scenario 1 assumes that LSD spread affects 3.42 percent of Asia's cattle population (median value for Middle East countries); for scenario 2, further spread of LSD puts 10.52 percent of Asia's cattle population at risk (mean value for Middle East countries). Each scenario estimated losses assuming high and medium impact. Annex 2 summarizes the parameters for each scenario. As shown in Table 3, LSD can cause up to USD 1 459 million in direct losses if it puts 10.5 percent of Asia's cattle and buffalo population at risk. Mortality and milk production losses account for most direct losses: mortality represents between 67 percent and 71 percent of such losses, while milk production losses range from 17 to 23 percent.

Since buffaloes and indigenous cattle are more resistant to LSD than exotic breeds, these estimates were constructed using different parameters related to morbidity and the impact of LSD according to the species or type of cattle.[4] However, there is high uncertainty around these parameters due to lack of research on LSD, including Asian breeds. As with any exotic disease, uncertainty around the impact estimates is high as many factors can influence the impact of LSD in countries that have never before reported the disease. The overall morbidity rate in India was 7.1 percent, with a lower morbidity rate observed in backyard small holdings (Sudhakar *et al.*, 2020). In Nepal, preliminary reports indicate an overall morbidity of 4.85 percent with higher morbidity in cattle (7.23 percent) as compared to buffaloes (2.44 percent) with an average milk reduction of 58.7 percent (FAO Nepal, personal communication, 2020). This is lower than the rate used for cattle (18.5 percent) but higher than for buffaloes (2.9 percent). These estimates are in line with the parameters used for high-impact scenarios.

Additional research and high-quality outbreak investigations in affected Asian countries can elucidate how LSD affects indigenous Asian breeds and increase the accuracy of impact estimates.

In addition to direct losses, detection of an exotic disease usually has severe trade implications for newly infected countries. Countries free of the disease may impose movement and trade bans on certain products considered risky for disease introduction in an attempt to protect their national herd. Asian exports of live cattle and buffaloes, meat and meat products, dairy products and hides accounted for USD 5 510 million in 2017 (Table 4). Therefore, trade losses associated with LSD can be substantially higher than the direct losses if trading partners respond by banning imports of cattle and buffalo products from infected

[4] Mortality rates for exotic and crossbred cattle mimic those reported in Middle East countries: 4.60 percent and 8.10 percent for the medium and high scenarios, respectively. Mortality rate for indigenous cattle is divided by 2 and for buffaloes is negligible.

TABLE 3
LSD-related direct losses estimated for different scenarios (unit: USD 1 000).

	Scenario 1		Scenario 2	
	Medium	***High***	***Medium***	***High***
Mortality loss	181 971	319 543	559 748	982 922
Milk loss	43 581	108 206	134 055	332 845
Weight loss	8 951	24 670	27 532	75 885
Hides loss	15 957	15 957	49 085	49 085
Draft power loss	5 977	5 977	18 385	18 385
Total	**256 437**	**474 354**	**788 805**	**1 459 123**

For scenario 1, LSD spread affects 3.42 percent and for scenario 2, further spread of LSD puts at risk 10.52 percent of Asia's cattle population.

TABLE 4
Asian exports at risk, 2017 (unit: USD 1 000).

Live animals	289 519
Meat and meat products	1 130 938
Milk	2 497 041
Butter and cheese	1 106 390
Yoghurt	320 586
Hides	165 617
Total	**5 510 091**

countries, which in turn can result in lower investments in the cattle sector. This impact may be mediated through negotiations between those partners and trade continuing between partners with similar disease status.

While global trade in raw hides is relatively small (USD 6 225 million on average between 2012 and 2014) and Asia's contribution is below 4 percent, manufacturing industry's reliance on hides as a key input is substantially larger and could also be disrupted by LSD. For instance, between 2012 and 2014 annual global exports of finished leathers and footwear with leather uppers averaged USD 76 000 million, of which 41 percent originated in Asia. According to the French Leather Council, Asia contributed 59 percent of global exports of all leather goods in 2017.

The short-term costs associated with LSD outbreaks can increase substantially when considering the response, with costs related to diagnosis capacity, outbreak investigations, stamping out the disease, compensation, cleaning and disinfection, treatment, vaccination, surveillance and awareness campaigns. Between 2016 and 2017, response costs in three Balkan countries ranged between 42.3 and 99.8 percent of the total costs associated with LSD outbreaks (Casal *et al.*, 2018). These figures do not take into account the potential impact on trade, the difference between countries being mainly explained by variations in

TABLE 5
Estimated costs in USD of LSD vaccination (vaccine costs) in affected countries of Asia (Bangladesh, Bhutan, China, India, and Nepal)

	Infected provinces	Infected + neighbouring
No. of vaccines needed	129 675 795	331 612 731
Cost of vaccines	142 875 668	356 014 502

stamping out and compensation policies. Applying a modified stamping out policy for severe clinical cases only with timely and close to market price compensation, reduces disease losses substantially at the expense of response costs, shifting losses from private to public funds.

The costs of vaccinating cattle in affected countries are estimated. They include the direct cost of procuring the vaccine, as well as the actual vaccination. On this occasion, only vaccine procurement costs were taken into consideration, assuming that all cattle and buffaloes in provinces (Adminstrative Unit 1) with outbreaks within infected countries (Bangladesh, Bhutan, China, India, Nepal) would be vaccinated, plus those in neighbouring provinces in order to prevent further spread of disease. The cost effectiveness of a vaccination programme depends on the type of vaccine, the coverage rate and the cost of vaccine delivery.

Taking into account the costs (Table 5), vaccination is economically justified under any scenario, since the costs are lower than the estimated direct losses, compared to other control strategies like stamping out. Incorporating potential trade losses increases the benefits of vaccination before the disease can spread to other territories. However, while the decision to vaccinate is economically beneficial for the entire region, the costs are borne by infected countries only. Considering the positive externalities associated with vaccination, regional funding mechanisms could absorb part of the vaccination costs.

Depending on the role that livestock play in society, the impact of infectious animal diseases usually goes beyond the economic dimension. For example, although the Asian dairy sector has seen the emergence of corporate-style large or mega farms, traditional smallholder systems remain dominant (Staal *et al.*, 2016). This implies that animal diseases such as LSD threaten livelihoods of smallholders who rely on milk production for their own food security and for income generation. Milk and dairy products play an important nutritional role throughout life, but especially in childhood development (Muehlhoff, Bennett and McMahon, 2013). The contribution of dairy products to prevent stunting is substantially higher than those of eggs or meat (Headey, Hirvonen and Hoddinott, 2018). Considering that up to 50 percent of milk produced is retained for domestic consumption in some parts of Asia (Kumar, Staal and Singh, 2011), LSD may also have a profoundly negative if indirect impact on people's health.

Taking into account that around two-thirds of the 600 million poor livestock keepers globally are female (FAO, 2012), women are particularly exposed to the impacts of animal diseases. Dairy cooperatives have contributed substantially to women's empowerment in India (Dohmwirth and Liu, 2020), where women account for 93 percent of total employment in dairy production (Qureshi, Khan and Uprit, 2016). By reducing milk yields, profits and employment in that sector, LSD can contribute to widening gender inequality. Therefore, to address the impact of LSD in Asia requires the design and implementation of gender-sensitive policies.

Disease control options

In Asia, the naïve population of cattle and buffaloes is likely to be more susceptible to LSD. High cattle and buffalo density in villages and communal sharing of watering and grazing areas limit the efficacy of short distance movement restrictions, aided by vector mediated transmission of disease. Flying biting insects, as well as ticks, potential vectors for the LSD virus, are another challenge for the control of this emerging disease. Lack of efficiently regulated and biosecure livestock production and market chains, coupled with lack of traceability and certification processes can lead to rapid LSD spread, nationally and beyond international borders. The religious and cultural affiliations of people in the south and eastern regions of Asia do not favour culling infected animals. Most countries lack funding and regulations for timely and fair compensation to farmers for culled animals. Any stamping out policy is hampered in many countries affected by LSD or at high risk of its introduction.

There are outstanding knowledge gaps related to LSD epidemiology, vector ecology, efficacy and cost-effectiveness of the different control options. Furthermore, countries are lacking a large enough number of doses of potent and safe LSD vaccines and the logistic and technical capacities for mass vaccination of large numbers of susceptible animals. Therefore, the veterinary services of affected and at risk countries, with no previous experience dealing with LSD, face serious challenges to develop effective LSD controls.

In response to the geographical expansion of LSD in the Russian Federation and the Balkans in 2015–2017, FAO published an LSD field manual for veterinary professionals, paraprofessionals and diagnosticians (Tuppurainen, Alexandrov and Beltrán-Alcrudo, 2017) and a position paper on sustainable prevention, control and elimination of LSD in Eastern Europe and the Balkans (FAO, 2017b). Additional materials and tools were developed to assist countries, including an online training course on LSD preparedness, a contingency plan template enriched with appendices on risk assessment questions, emergency vaccination planning, surveillance (for early detection) and prevention measures, awareness leaflets/posters and videos, and a cost-benefit assessment tool.

In each country and region where LSD outbreaks occur, the control and eradication measures need to be adjusted to local settings, taking into consideration the size of the susceptible cattle population, local cattle farming practices, LSD risk factors and social and religious traditions and beliefs. These regionally specific factors will determine which control and eradication measures are feasible and/or can be realistically implemented successfully. Countries need to decide on achievable, feasible policy goals, to become involved in a regional discussion, to ensure that national policy goals are compatible with each other and to harmonize control measures.

In general LSD control is based on: 1) vaccination of susceptible populations with >80 percent coverage; 2) movement control of cattle and buffalo and quarantine; 3) biosecurity and vector control; 4) strengthening active and passive surveillance; 5) awareness raising on risk mitigation among all stakeholders involved; and 6) zoning – large protection and surveillance zones and vaccination zones. Table 6 lists available prevention and control approaches.

TABLE 6
LSD prevention and control approaches

Expected outcomes	Control options	Challenges within South and East Asian countries
1. Preventing introduction of disease	• National legislation and contingency plan available for LSD • Strict regulations and testing requirements for live cattle imports and border inspection with quarantine of all incoming livestock • Awareness raising on the clinical manifestation of LSD within farming communities; communication on risk mitigation with farmers and other stakeholders • Enhanced active and passive surveillance • Enhanced biosecurity and vector control measures on farms and along value chain • Pre-emptive vaccination with effective vaccines against LSDV	• No contingency plan or written guidelines available on LSD prevention, control, eradication and surveillance • Large-scale official trade and unofficial cross-border movement of cattle • As LSD is a new disease, lack of awareness and knowledge for veterinarians and farmers in South, East and Southeast Asia, • Prevailing low input backyard/subsistence farming with poor hygiene and biosecurity practices • Abundance of blood-feeding vectors and presence of suitable insect breeding sites (standing water and manure) at a farm • Vaccine stocks and cold chain infrastructure not always available for quick deployment
2. Immediate containment and eradication once disease is introduced in a limited area in country	• Swift regional vaccination using vaccines with proven efficacy against LSD and a minimum 80 percent vaccination coverage • Quick stamping out of infected animals and offering farmer compensation: fair and timely and/or slaughter campaigns • Carcass disposal, cleaning and disinfection • Epidemiological investigations and tracking the spread of the virus • Ban on cattle and buffalo movements and zoning • Enhanced active and passive surveillance • Awareness raising on clinical manifestation of LSD and communication with farmers and other stakeholders on LSD risk mitigation • Implementation/availability of cattle identification and vaccination records system • Vector control at farm and animal level	Similar to prevention of the introduction of the disease (see above) • No funding dedicated or available for compensation and no approved compensation plan • Large animals like cattle and buffalo difficult to dispose of (for advice see FAO Focus On: http://www.fao.org/3/CA2073EN/ca2073en.pdf) • Stamping out and culling not accepted in certain cultures • Ban on cattle and buffalo movement is expensive and complicated for many countries, therefore it is not always feasible due to lack of facilities for temporary standstill with effective prevention of contacts between animals, vector control, cleaning of stables, feeding and watering of cattle and buffaloes • Most countries in the region do not have a cattle identification system
3. Efficient and quick control of the disease with possibility of eradication in 3-5 years.	• Swift regional vaccination using vaccines with proven efficacy against LSD and a minimum 80 percent vaccination coverage • Vector control • Movement control and zoning • Awareness raising and communication on LSD risk mitigation to farmers and other stakeholders • Identification and traceability of animals with recording of vaccination	• Most countries in the region do not have a cattle identification system • Adequate cold chain for vaccine delivery is difficult to maintain in prevailing climatic conditions • Harmonization across areas/right time for vaccination is key but requires regional cooperation and collaboration • Few laboratories exist in the region to ensure quality and safety control of batches of vaccine (evidence of absence of bacterial, fungal, mycoplasmal and viral contaminants safety, potency) as well as appropriate validation for use and dose of heterologous vaccines (ten-fold doses)
4. Endemic situation **Lost animals, damaged hides, reduced milk productivity, infertility**	No action taken	• Food security and nutrition balance loss (e.g. energy, protein, vitamins and minerals) due to key role of milk and dairy products in diets, especially in countries with population following Hinduism and Buddhism • High socio-economic impact, especially on female smallholders • Trade restrictions

CATTLE MOVEMENT CONTROL

Standstill and quarantine are the very first measures to be undertaken quickly, especially at first detection of the disease in a country or region. This also applies to at risk areas bordering neighbouring countries which report LSD. Movement control zones should be kept as small as possible, and clinical surveillance in at risk regions should be implemented.

VECTOR CONTROL

As a sole measure vector control cannot prevent infection or spread of LSD but should be considered a supportive measure. Vector control can be achieved by regular use of pour-on repellents and insecticides for cattle and buffaloes with other insect control systems in barns and farm premises. It is important to select a repellent that is effective against the local insect or tick species. When using insecticides, withdrawal times for milk and meat need to be considered. Large-scale use of insecticides in the environment is not recommended as they may be harmful to the ecological balance and to other useful insects such as honeybees and pollinators. Insecticide-impregnated netting is being investigated as a way to reduce vector attacks on livestock and may be helpful where husbandry systems make it practical (FAO, 2013c)

Regular and thorough cleaning, disinfection of barns and other premises where susceptible livestock are kept in addition to clearing or limiting vector breeding sites, such as standing water sources, slurry and manure and improved drainage of holdings are important general measures, even in the absence of disease.

VACCINATION

Vaccination of cattle using a vaccine with demonstrated efficacy is the best option for controlling the spread of LSD, especially if pre-emptive, i.e. applied before the virus enters a region or country at risk. However, preventive vaccination against LSD leads to trade restrictions on the export of live cattle and their products, which may deter disease-free exporting countries from implementing pre-emptive vaccination in high-risk regions.

Pre-emptive vaccination is highly recommended when LSD is detected across borders in neighbouring countries. It may take the form of zone or buffer vaccination, taking into account geographical barriers, transport access routes and host population densities (FAO, 2017b).

Emergency vaccination is an immediate response to an outbreak within the country. It must be performed immediately after the detection of the first case. In the field, the first cases of LSD are usually not detected early enough as the time window between infection and viraemia is one to five days, during which it is impossible to identify infected animals. In addition, in early stages of the disease, non and mild clinical cases may be difficult to recognize, even for the most experienced veterinarians. Emergency vaccination can be applied in the form of barrier vaccination, blanket vaccination, ring vaccination or targeted vaccination (OIE, 2019b).

Where there is localized presence of the disease and existing natural barriers and means for cattle identification, a country may be divided into vaccinated and non-vaccinated zones. Regional vaccination is preferable to ring vaccination, given the challenges in detecting early cases, and requires efficient movement control, particularly between zones with different infection status. The extent of the vaccinated zones should be based on epidemiological and geographical or country statutory (district, province etc.) parameters rather than the classical radius shape.

After deciding on the objectives of a vaccination programme, its success mainly depends on efficacy of the vaccine product, efficient delivery (transport, cold chain, suitable equipment, correct dosage, application and biosecurity) and sufficient vaccination coverage (80–100 percent). Other important factors include: i) capacities authority, funding and sufficient personnel for the veterinary services to carry out the vaccination campaign, other control/eradication measures and surveillance programmes; ii) data availability including cattle ID/ vaccination/health records/cattle movement history and database access; iii) regulation of cattle trade and cattle movements; and iv) diagnostic capacity of national reference and sub-national laboratories.

The success of LSD control and eradication in Israel and the Balkan region of Europe was based on repeated annual vaccination for several years after the cessation of clinical cases. Harmonized and risk-based timing of vaccination campaigns across regions provide the best protection and should be carried out prior to large-scale movements of cattle and buffaloes, for example prior to seasonal grazing or festivals, where demand for meat is high. Newly purchased animals should be vaccinated before introduction to farms. The vaccination should be implemented on the farm of origin and before movement to auction yards or live animal markets. Calves from vaccinated/naturally infected mothers should be immunized at the age of three to four months, either individually or during the next round of scheduled vaccinations but time enough before the higher risk season for re-incursion.

Vaccinations are often started when the virus is already present and spreading in the region. It is important to note that maximum protection is achieved approximately three weeks post-vaccination. If vaccination takes place when the disease is already suspected in the herd, village or epidemiological unit, vaccination of non-clinical animals can still take place, but taking care to use only a new or sterilized needle for each animal.

Vaccines

Presently only live, attenuated vaccines are available against LSD virus. There is ongoing research and development of inactivated vaccines. Three groups of vaccines offer good protection against LSDV in cattle (see Annex 3): attenuated vaccines based on LSD, SPP or GTP viruses. Vaccines should be produced under good manufacturing practices (European Union, 1991) and and according to OIE standards.[5] Efficacy testing is required prior to applying the vaccine. Vaccine challenge experiments should be carried out at specialized authorized laboratories only. The vaccine selected for use in a country should meet the recommendations of the International Cooperation on Harmonisation of Technical Requirements for Registration of Veterinary Medicinal Products programme[6] and should comply with the regulatory approval procedure of the country. In addition, vaccines should be manufactured in accordance with the principles set out in the OIE standards for veterinary vaccines/biologicals (OIE, 2019c).

5 OIE manual of diagnostic tests and vaccines for terrestrial animals 2019, Chapter 3.4.12 and 3.7.12

6 https://vichsec.org/en/

Attenuated LSDV vaccines

Currently, there are three vaccine producers manufacturing attenuated homologous LSDV vaccines. Live, attenuated LSDV vaccines provide good protection in cattle if 80 percent coverage can be attained. There is evidence of mild adverse effects of attenuated LSDV vaccines called the ''Neethling response”. At the same time, according to recent studies, after vaccination with live attenuated Neethling LSD vaccine, there is no significant change in mortality or milk production during the 30 days post-vaccination and no difference between the pre- and post-vaccination periods in routine culling, immediate culling and in-farm mortality for those animals vaccinated for the first time (Morgenstern and Klement, 2020).

Attenuated SPPV vaccines

SPPV vaccines at a higher dose (three, five and ten-fold) have been used in cattle against LSDV in those regions where LSD and SPP are both present. As the protection provided by SPPV vaccines against LSDV is believed to be partial, selection of the vaccine should always be based on its demonstrated efficacy against LSDV by a challenge trial carried out in a controlled environment. The ten-fold dose of attenuated SPPV vaccines is recommended for immunization of bovines against LSD. Nevertheless, compared to the Neethling vaccine its efficacy is significantly lower (Ben Gera *et al.*, 2015).

Attenuated Gorgan GTPV vaccine

Commercially available GTPV Gorgan strain has been demonstrated to provide the same protection against LSD as the LSDV vaccines (Gari *et al.*, 2015). Gorgan GTPV vaccine is a good, cost-effective alternative in those countries where GTP and LSD overlap. Recent data from Kazakhstan also enhance our understanding of the potential use of GTPV where the goatpox vaccine strain for LSD elicited a strong protective immune response in cattle (Zhugunissov *et al.*, 2020).

In India the GTPV Uttarkashi strain is being evaluated for level of protection against LSD as compared to the LSDV vaccine and is already used for emergency vaccination. In Bangladesh GTPV vaccine was used in Chattogram and found to be effective against LSD (*Dhaka Tribune*, 2020; Kayesh *et al.*, 2020)

Considering the positive experience in LSD control in Israel and the Balkan region of Europe as well as recent studies, control programmes based on mass annual vaccination using live, attenuated LSDV vaccine should be the preferred option. With successful testing, validation and approval, the GTPV Uttarkashi strain vaccine could be a more affordable option that is more quickly available and useful for large scale immunization programmes. There are also several studies of the GTPV vaccine based on the Gorgan strain with successful results (Zhugunissov *et al.*, 2020).

Surveillance

The objectives of surveillance include early detection of LSD and/or proof of freedom from the disease. The sample types are skin lesions and scabs, saliva or nasal swabs, EDTA blood for PCR assay, and whole blood for serology. Both passive and active surveillance can be in place using the appropriate diagnostic test (clinical examination, PCR, and ELISA), each time

time defining the design prevalence (threshold of detection). A manual and the associated tool (sampleator) exist to calculate sample size.[7]

Passive surveillance is very effective in naïve populations due to the typical and visible clinical signs of LSD. In immunised populations the clinical signs are less clear and as a result passive surveillance may not contribute much to early detection of the disease. In populations where vaccination was or is still being implemented, active surveillance based on clinical examination (67–75 percent sensitivity in experimental trials) and PCR test confirmation on skin and blood samples is shown to be more effective. Active surveillance can target at risk areas (e.g. areas bordering infected countries). As per OIE, guidelines stipulate that "surveillance in a free country or zone should be carried out over an appropriate distance from the border with an infected country or zone, based upon geography, climate, history of infection and other relevant factors" (OIE, 2020). European guidelines set a protection zone of 20 km and a surveillance zone of 50 km (Council Directive 92/119/EEC, 1992) but each country should make a decision based on relevant ecological and geographical features, production systems, animal movements and value chains within and between them.

Surveillance is also an essential component of the control programme e.g. emergency vaccination, by: 1) examining animals outside the vaccination zone to prove the disease did not escape the vaccination zone; 2) clinically checking animals in the vaccination zone prior to vaccination to confirm they are free of LSD; and 3) reporting and investigating any adverse reaction to the vaccine. Surveillance should take place both outside (in a 20–50 km zone starting from the borders of the vaccination zone) and inside the vaccination zone, before and after vaccination. Ideally, all farms and herds should be examined prior to vaccination, to rule out the clinical presence of the disease. The vaccination team can do this at the time of vaccination, by calling the animal owner or handler to certify the animals do not show clinical signs, or by sending surveillance teams prior to the arrival of the vaccination team. Surveillance activities should take place uniformly during the 28-day post vaccination period to detect LSDV already in incubation or any adverse reaction due to the vaccine (FAO, 2019).

Awareness

Efficient disease control is impossible without good cooperation among farmers and other cattle value chain actors. Awareness campaigns should be targeted at official and private veterinarians, both in the field and in abattoirs, among veterinary students, farmers, herders, cattle traders, cattle truck drivers and artificial inseminators. Cattle truck drivers are in a particularly good position to identify infected animals on farms, in slaughterhouses, or at cattle collection and resting stations and to notify veterinary authorities about any clinical suspicion as soon as possible (Tuppurainen, Alexandrov and Beltrán-Alcrudo, 2017).

Awareness of farmers, pastoralists, veterinarians, butchers and other relevant stakeholders is crucial to improve passive surveillance for early LSD detection and control. It also contributes to higher levels of biosecurity to prevent LSD introduction into the country or the herd and ensure rapid detection and an early, more efficient response to outbreaks.

A range of FAO training and awareness materials and tools are available that can be adapted to country contexts.[8]

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7 See https://zenodo.org/record/167307#.X61nRqecb5a

8 See http://www.fao.org/europe/resources/transboundary-animal-diseases-leaflets/en/

OTHER CONTROL MEASURES

In most countries of South, East and Southeast Asia a stamping out policy is not feasible due to religious beliefs and cultural traditions, as well as economic and epidemiological considerations. Stamping out is difficult to pursue due to lack of compensation funds and the challenges of humane slaughter and carcass disposal in line with animal welfare and infectious disease control requirements in the vast majority of countries. Culling infected animals is therefore not a recommended option for these countries.

In countries where a total or partial stamping out measure is feasible, this will increase the effectiveness of other measures, leading to faster disease control and eradication. In such countries where culling and disposal of infected animals is feasible and there is a government compensation fund it is important to effect stamping out quickly at first detection of the disease. If not, stamping out will not be an efficient control measure and for preference should not be undertaken. For it to be effective, cases must be clinically recognized, preferably confirmed rapidly in a laboratory, humanely culled and disposed of appropriately and as soon as possible. According to the European Food Safety Authority (EFSA) low reporting rates of clinical disease (~50 percent) reduce the possible benefits of this approach (EFSA, 2015). Reporting decreases even more when compensation for stamping out is not timely, fair, well-regulated or applied consistently. Stamping out should never take place in isolation, but in combination with movement control, tracing and surveillance, zoning and compartmentalization, awareness campaigns and emergency vaccination.

If total stamping out is not an option, animals with clinical signs must always be removed from the herd as soon as possible and disposed of safely. See FAO's Focus On: Carcass management for small- and medium-scale livestock farms (Miller and Flory, 2018) for practical guidance on safe carcass disposal.

Slaughtering and processing of the carcass for consumption is an option to reduce virus load and virus spread without culling, especially in smallholder and backyard systems. It is always difficult to justify throwing away non-infected or suspected animals without clinical symptoms. Allowing farmers to sell the carcass will reduce economic losses and improve reporting. Cattle slaughtered with clinical signs are not suitable for human consumption. However, if these animals are treated with antibiotics and anti-inflammatory drugs, following recovery and drug withdrawal period they are safe for human consumption.

DISCUSSION AND RECOMMENDATIONS

The cattle and buffalo trade in Asia is versatile and dynamic, although fragile, reflected in the rapid shifts in trade flows following new regulations implemented by countries, the introduction or spread of animal diseases, tough competition for the cattle market from countries outside Asia, and the political environment, among others. Given the number of countries reporting LSD in recent months, Bangladesh, Bhutan, China, India and Nepal, and the extent of the live cattle and buffalo trade during which it is unlikely biosecurity measures are taken, the spread of LSD across Asia is a tangible, imminent major threat to animal health, welfare and the regional economy.

This risk assessment indicates Cambodia, Lao People's Democratic Republic, Myanmar, Thailand and Viet Nam are at high risk of LSD introduction. The main risk pathways are the significant informal trade in cattle and buffalo and their products between these countries and LSD-affected countries, poor biosecurity in bovine production systems and along the value chain and the moderate abundance of vectors during the period, i.e. October–December. It is interesting to note that the Indian LSDV isolates are closely related to the strains from Kenya rather than from Europe, (Sudhakar *et al.*, 2020) suggesting the disease can make long distance jumps along trading corridors.

Once introduced, further spread into non-infected areas with high densities of susceptible animals and the presence of suitable vectors is anticipated, especially when early detection or movement control are not possible. Future studies mapping the risk of LSD spread, using modelling approaches including host and ecoclimatic variables are encouraged to inform surveillance for early detection (Allepuz, Casal and Beltrán-Alcrudo, 2019).

In general, vaccination of cattle using a vaccine with demonstrated efficacy is the best option for controlling the spread of LSD and reducing direct and indirect economic losses. Mass vaccination using live attenuated homologous vaccine (LSDV) demonstrated better results in controlling and eradicating LSD in Europe (the Balkans) and Israel than the application of SPPV vaccine in other regions. Vaccination with a ten-fold dose of heterologous vaccine could be considered an alternative option where sheep and goatpox are present. Among heterologous vaccines, preference is given to GTPV. The quality and safety control of each batch of both homologous (using LSDV) and heterologous (using GTPV or SPPV) vaccines must be ensured. It is important to conduct vaccination according to professional and biosecurity standards to avoid iatrogenic transmission of the disease when vaccinating or treating animals. This could lead to the fast and wide spread of LSD if outbreaks occur during mass vaccination campaigns.

The cost effectiveness of vaccination provides a strong economic justification for it. However, while controlling disease with vaccination is economically beneficial for the entire region, the costs are borne by the vaccinating countries only. Considering the positive externalities associated with vaccination and high risk for progressive spread and endemicity in South and East Asia, regional funding mechanisms could absorb part of the vaccination costs.

If stamping out is applied, a compensation scheme should offer fair and timely compensation to owners of culled animals. It is advisable to agree compensation with stakeholders and policymakers in advance, even before the first LSD introduction, to prepare an adequate budget and make sure the legislation, authority and means are in place to complete the culling effectively and smoothly.

The vector ecology linked to LSD in this region requires further studies to develop and implement technically safe, sound, cost efficient and environmentally friendly vector control programmes.

It is recommended that countries at high risk of LSD introduction implement the following:

1. Strict border inspection of all susceptible imported animals with a compulsory clinical inspection, quarantine and testing regime. Make sure to have suitable facilities, feed, manpower and budget to hold quarantined animals over time, with minimal risk of spread to local animals.
2. Pre-emptive vaccination of all susceptible animals in wide enough strips along high risk zones bordering on infected neighbouring countries, long enough before the

high incursion risk is anticipated or from other areas with high risk of LSD incursion. Vaccination strips should ideally be set approximately up to 80 km from the border. Countries need to consider also other factors such as terrain, mountains, waterways, roads and density of cattle populations. This only applies if the vaccine is already available for use in that country.

3. Active clinical surveillance and awareness campaigns on clinical disease signs, prevention and control among practitioners and government and private veterinarians and paraprofessionals, border inspectors, famers, traders and other actors in the cattle/buffalo value chain for early detection of first cases of the disease. Developing specific gender sensitive awareness raising programmes for women farmers is recommended, as their engagement is likely to improve early disease detection and prevent further spread.
4. Improved biosecurity at all levels of the cattle/buffalo production and value chain, as well as cleaning, disinfection and vector control. It is most important to control the introduction of new animals into the herd. This should be preceded by quarantine and/or testing.
5. Points 1 to 4 should be part of a detailed national contingency programme, along with guidelines on slaughter, carcass disposal and the use of meat for consumption.

Countries at moderate risk should follow all the above recommendations except 2. Low risk countries should monitor the situation closely with a high level of preparedness in terms of contingency planning, as and when the risk level changes.

Countries that have already suffered LSD introduction are recommended to:

1. Control movement of susceptible animals and zoning/regionalization, set up road check points and establish authorised, trained units to enforce these measures.
2. Perform a mass vaccination programme targeting all susceptible animals, with regular post-vaccination monitoring to evaluate the programme's effectiveness.
3. Apply humane slaughter methods – if stamping out is permitted by law – observing animal welfare standards, with compensation as applicable within national legislation. Slaughtering campaigns, if implemented, must observe withdrawal periods for animals that have been medicated.
4. Enhance active surveillance in high risk areas and a high level of disease awareness to improve early detection and facilitate containment.
5. Improve biosecurity at all levels of the cattle/buffalo production and value chain, including cleaning, disinfection and vector control. In addition, training in biosecurity practices for smallholders, women farmers, traders and market operators is essential to minimize spread.
6. Give timely notification to neighbouring countries and relevant international organizations according to international regulations.

Collaboration between infected and at risk countries sharing borders is paramount to exchange information on disease prevalence, applied control measures, vaccines being used, and post-vaccine sero-monitoring. Regular collaboration and constant communication build trust and will enable resumption of bilateral trade, minimizing economic losses for both sides.

Areas of uncertainty and outstanding gaps

Despite recent intensive European studies following the emergence of LSD in Europe and the Middle East there are still many knowledge gaps about the biology, host responses and epidemiology of this disease. Future collaboration is paramount between experts, reference centres, veterinary services and international and regional organizations in infected and at risk countries. Among the most urgent priorities that require better understanding are:

1. Using challenge trials to test the efficacy of locally available vaccines against LSD.
2. Establishing the rate of onset, duration of immunity and protection from vaccination.
3. Clarifying the epidemiological significance of animals with subclinical infection (due to innate or acquired immunity or a low infection rate, including small ruminants) in the spread or maintenance of LSDV.
4. Informed vector control programmes on vector ecology in different regions as well as vector species involved in LSDV transmission, and the distance and time span over which they can transmit infection.
5. Virus survival in inter-epizootic periods.
6. The possibility of simultaneous administration of LSDV vaccine with other obligatory vaccines (such as FMD or brucellosis) and any adverse effect on sero-conversion or protective immunity.
7. Inclusion of attenuated LSDV vaccination into cattle testing regimes, such as intradermal tuberculin testing.

FAO is closely monitoring the disease situation through media and country reports via the Global Animal Disease Information System – EMPRES-i. This feeds into continuous risk assessment, early warning and communication to affected and at risk countries and mechanisms that provide continuous support through Incident Coordination Groups run by the FAO Emergency Management Centre for Animal Health (EMC-AH). We plan to review existing risk assessment in 3-6 months to monitor if the assessment held true. It will be updated as the epidemiological situation changes.

A regional approach is the only effective way to target transboundary animal diseases such as LSD, through harmonized prevention and control measures, such as vaccination programmes, as well as creation of regional fora where countries can share information, lessons learnt and best practices. Cooperation among all stakeholders (farmers, traders, processors, veterinarians, and other cattle/buffalo value chain actors and industry associations) is crucial for optimal success. Raising awareness and active engagement of these groups will improve collaboration in early detection and the effective, timely implementation of any prevention and control measure. FAO supports countries in identifying solutions best fitted to their circumstances, exploring and piloting new approaches for risk mitigation and outbreak control if needed.

There is a high risk of a potentially endemic situation in the region with disastrous socio-economic consequences. FAO encourages and supports countries in the urgent need for regional coordination to control LSD in Asia and prevent further spread.

References

Abutarbush, S.M. 2014. Efficacy of vaccination against lumpy skin disease in Jordanian cattle. *Vet. Rec.*, 175(12): 302–302. (also available at https://doi.org/10.1136/vr.102271).

Abutarbush, S.M., Ababneh, M.M., Zoubi, I.G.A., Sheyab, O.M.A., Zoubi, M.G.A., Alekish, M.O. & Gharabat, R.J.A. 2015. Lumpy skin disease in Jordan: disease emergence, clinical signs, complications and preliminary-associated economic losses. *Transbound. Emerg. Dis.*, 62(5): 549–554. (also available at https://doi.org/10.1111/tbed.12177).

Alemayehu, G., Zewde, G. & Admassu, B. 2013. Risk assessments of lumpy skin diseases in Borena bull market chain and its implication for livelihoods and international trade. *Trop. Anim. Health Prod.*, 45(5): 1153–1159. (also available at https://doi.org/10.1007/s11250-012-0340-9).

Allepuz, A., Casal, J. & Beltrán-Alcrudo, D. 2019. Spatial analysis of lumpy skin disease in Eurasia-predicting areas at risk for further spread within the region. *Transbound. Emerg. Dis.*, 66(2): 813–822. (also available at https://doi.org/10.1111/tbed.13090).

Annandale, C.H. 2020. Reproductive effects of lumpy skin disease virus in cattle – Chapter 5. Universiteit Utrecht. (PhD dissertation). (also available at https://doi.org/10.33540/37).

Annandale, C.H., Holm, D.E., Ebersohn, K. & Venter, E.H. 2013. Seminal transmission of lumpy skin disease virus in heifers. *Transbound. Emerg. Dis.*, 61(5): 443–448. (also available at https://doi.org/10.1111/tbed.12045).

ANSES. 2017. Risk of introduction of lumpy skin disease into France: ANSES opinion–collective expert report. March 2017, Scientific Edition. Maisons-Alfort, France. (also available at https://www.anses.fr/fr/system/files/SABA2016SA0120RaEN.pdf).

Asia Beef Network. 2020. Country Profiles - Australia, Cambodia, China, Indonesia, Laos, Myanmar, Thailand, Timor-Leste, Viet Nam. In: Asia Beef Network [online]. Hanoi, Viet Nam [Cited 10 August 2020]. (also available at www.asiabeefnetwork.com/country-profiles).

Asian Development Bank. 2015. ADB project document: livestock movement and disease risk in the Greater Mekong Sub-region – a rapid assessment. September 2015. Manila, The Philippines. (also available at http://bearecon.com/portfolio-data/adb-lits/adb-lits-rapid-assessment.pdf).

Babiuk, S. 2018. Persistence and stability of the virus. In Tuppurainen, E.S.M., Babiuk, S. & Klement, E., eds. *Lumpy skin disease*, Cham, Switzerland, Springer. 45–46. (also available at https://doi.org/10.1007/978-3-319-92411-3_11).

Babiuk, S., Bowden, T.R., Parkyn, G., Dalman, B., Manning, L., Neufeld, J., Embury-Hyatt, C., Copps, J. and Boyle, D.B. 2008. Quantification of lumpy skin disease virus following experimental infection in cattle. *Transbound. Emerg. Dis.*, 55 (7):299–307. (also available at https://doi.org/10.1111/j.1865-1682.2008.01024.x).

Barnard, B.J. 1997. Antibodies against some viruses of domestic animals in southern African wild animals. *Onderstepoort J Vet Res*, 64(2):95-110.

Ben-Gera, J., Klement, E., Khinich, E., Stram, Y. and Shpigel, N.Y. 2015. Comparison of the efficacy of Neethling lumpy skin disease virus and x10RM65 sheep-pox live attenuated vaccines for the prevention of lumpy skin disease - the results of a randomized controlled field study. *Vaccine*, 33(38): 4837-4842. (also available at https://doi.org/10.1016/j.vaccine.2015.07.071).

CAMS (Center for Agricultural Market Studies). 2020. Export potential analysis of Mongolian livestock products to China. Bonn, Germany. (also available at https://connecting-asia.org/wp-content/uploads/2020/06/20200618_Export-potential-analysis-of-Mongolian-livestock-products-to-China.pdf).

Casal, J., Allepuz, A., Miteva, A., Pite, L., Tabakovsky, B., Terzievski, D., Alexandrov, T. & Beltrán-Alcrudo, D. 2018. Economic cost of lumpy skin disease outbreaks in three Balkan countries: Albania, Bulgaria and the Former Yugoslav Republic of Macedonia (2016-2017). *Transb. Emerg. Dis.*, 65(6): 1680-1688. (also available at https://doi.org/10.1111/tbed.12926).

CITES. 2020. Checklist of CITES Species. In: Convention on International Trade in Endangered Species of wild fauna and flora [online]. Geneva. [Cited 12 August 2020]. (also available at https://checklist.cites.org/#/en).

Coetzer, J.A.W, Tuppurainen, E., Babiuk, S. & Wallace, D.B. 2018. Lumpy skin disease. In Coetzer, J.A.W., Thomson, G.R., Maclachlan, N.J., & Penrith, M.L., eds. Infectious diseases of livestock, Part II. pp.1268–1276. Gauteng, South Africa, Anipedia. (also available at https://www.researchgate.net/publication/326258692_Lumpy_Skin_Disease).

Chihota, C.M., Rennie, L.F., Kitching, R.P. & Mellor, P.S. 2001. Mechanical transmission of lumpy skin disease virus by *Aedes aegypti* (Diptera: Culicidae). *Epidemiol Infect.*,126(2):317-321. (also available at https://doi.org/10.1017/s0950268801005179).

Council Directive 92/119/EEC, 1992. Introducing general Community measures for the control of certain animal diseases. (also available at https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A31992L0119).

Davies, F.G. 1991. Lumpy skin disease of cattle: a growing problem in Africa and the Near East. In World Animal Review, 68. Rome, FAO. 37–42. (also available at www.fao.org/3/u4900t/u4900t0d.htm).

Davies, F.G. 1982. Observations on the epidemiology of lumpy skin disease in Kenya. *J. Hyg.* London 88(1): 95–102. (also available at https://doi.org/10.1017/s002217240006993x).

DEFRA, Scottish Government and Welsh Government. 2018. Lumpy skin disease. Control strategy for Great Britain. June 2018 [online]. London. (also available at assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/720416/lumpy-skin-disease-control-strategy.pdf).

Dhaka Tribune. 2020. Vaccination to curb LSD epidemic of cattle. *Dhaka Tribune*, 11 January 2020. (also available at https://www.dhakatribune.com/bangladesh/nation/2020/01/11/vaccination-to-curb-lsd-epidemic-of-cattle).

Dohmwirth, C., & Liu, Z. 2020. Does cooperative membership matter for women's empowerment? Evidence from South Indian dairy producers. *J. Dev. Effect*, 12(2): 133–150. (also available at https://doi.org/10.1080/19439342.2020.1758749).

EFSA – European Food Safety Authority. 2019. Lumpy skin disease: workshop on risk assessment and data collection for epidemiology, control and surveillance. EFSA supporting publication 2019: EN-1751. 11 pp. (also available at https://efsa.onlinelibrary.wiley.com/doi/pdfdirect/10.2903/sp.efsa.2019.EN-1751).

EFSA. 2015. Scientific opinion on lumpy skin disease - Table 1. Period of detection of LSD in different matrices. *EFSA Journal*, 13(1): pp. 12. [online]. [Cited 8 August 2020] (also available at https://doi.org/10.2903/j.efsa.2015.3986).

Elhaig, M.M., Selim, A. & Mahmoud, M. 2017. Lumpy skin disease in cattle: frequency of occurrence in a dairy farm and a preliminary assessment of its possible impact on Egyptian buffaloes. *Onderstepoort J. Vet. Res.,* 84(1): e1– e6. (also available at http://dx.doi.org/10.4102/ojvr.v84i1.1393).

European Union. 1991. Directive 91/412/EEC Laying down the principles and guidelines of good manufacturing practice for veterinary medicinal products. *Off. J. Eur. Union*, L228:70–73. (also available at: http://ec.europa.eu/health/files/eudralex/vol-5/dir_1991_412/dir_1991_412_en.pdf).

Fagbo, S., Coetzer, J.A.W. & Venter, E.H. 2014. Seroprevalence of Rift Valley fever and lumpy skin disease in African buffalo (Syncerus caffer) in the Kruger National Park and Hluhluwe-iMfolozi Park, South Africa. *J.S. Afr. Vet. Assoc.*, 85(1):e1-e7. (also available at https://doi.org/10.4102/jsava.v85i1.1075).

FAO. 2012. Invisible guardians – Women manage livestock diversity. FAO animal production and health paper No. 174. Rome, Italy. (also available at http://www.fao.org/3/i3018e/i3018e00.htm).

FAO. 2013a. Final report on the research study on: To define and analyze cross-border and in-country livestock and livestock products market systems in Bangladesh. OSRO/RAS/901/EC. FAO internal document. Dhaka.

FAO. 2013b. Research study: To define and analyze cross-border and in-country livestock and livestock products market systems in India for control of transboundary animal diseases. OSRO/RAS/901/EC. Delhi, India. (also available at http://www.vethelplineindia.co.in/wp-content/uploads/2014/04/FAO_MSS_Final_Report_VHI_05032014.pdf).

FAO. 2013c. Netting flies and mosquitoes protects livestock, boosts milk yields. (also available at http://www.fao.org/news/story/en/item/173224/icode/).

FAO. 2014. Final report on study: To define and analyze cross-border and in-country livestock and livestock products market systems in Nepal. OSRO/RAS/901/EC. FAO internal document. Kathumandu, Nepal.

FAO. 2017b. Sustainable prevention, control and elimination of lumpy skin disease – Eastern Europe and the Balkans. FAO animal production and health position paper. No. 2. Rome. (also available at http://www.fao.org/3/a-i7827e.pdf).

FAO. 2019. FAO Appendix II: Guide to develop a lumpy skin disease emergency vaccination plan. Final version. 1 October 2018. Drafted: Mark Hovari, Daniel Beltrán-Alcrudo.

FAO. 2020. EMPRES-i Global Animal Disease Information System. In: *FAO Animal Production and Health Division* [online]. Rome. [Cited 15 August 2020]. (also available at http://empres-i.fao.org/eipws3g/).

FAOSTAT. 2020. FAOSTAT. In: Statistics Division [online]. Rome. [Cited 15 August 2020]. (also available at www.fao.org/ faostat/en/#home).

Gari, G., Abie, G., Gizaw, D., Wubete, A., Kidane, M., Asgedom, H., Bayissa, B., Ayelet, G., Oura, C.A.L., Roger, F. & Tuppurainen, E.S.M. 2015. Evaluation of the safety, immunogenicity and efficacy of three capripoxvirus vaccine strains against lumpy skin disease virus. *Vaccine*, 33(28):3256-3261. (also available at http://doi.org/10.1016/j.vaccine.2015.01.035).

Headey, D., Hirvonen, K., & Hoddinott, J. 2018. Animal sourced foods and child stunting. *Amer. J. Agr. Econ.*, 100(5): 1302–1319. (also available at https://doi.org/10.1093/ajae/aay053).

Irons, P.C., Tuppurainen, E.S.M. & Venter, E.H. 2005. Excretion of lumpy skin disease virus in bull semen. *Theriogenology*, 63(5): 1290–1297. (also available at https://doi.org/10.1016/j.theriogenology.2004.06.013).

Kitching, R.P. & Mellor, P.S. 1986. Insect transmission of capripoxvirus. *Res. Vet. Sci.*, 40(2):255–258. (also available at https://doi.org/10.1016/s0034-5288(18)30523-x).

Kamruzzaman, S. 2020. Outbreak of lumpy skin disease in Bangladesh. *Journal of Veterinary Studies and Animal Husbandry*, 1:6-8. (also available at https://www.sciworldpub.com/article-abstract?doi=101-JVSAH-20).

Kayesh, M.E.H., Hussan, M.T., Hashem, M.A., Eliyas, M. & Anower, A.K.M.M. 2020. Lumpy skin disease virus infection: an emerging threat to cattle health in Bangladesh. *Hosts and Viruses*, 7(4): 97-108. (also available at http://dx.doi.org/10.17582/journal.hv/2020/7.4.97.108).

Kumar, A., Staal, S.J. & Singh, D.K. 2011. Smallholder dairy farmers' access to modern milk marketing chains in India. *Agri. Econ. Res. Rev.*, 24(2): 243–253. (also available at https://doi.org/10.22004/ag.econ.118232).

Leye County. 2020. 封锁令—乐业县人民政府关于封锁牛结节性皮肤病疫区的命令. 乐业县人民政府令〔2020〕第1号 (Blockade Order—Order of the Leye County People's Government on the blockade of lumpy skin disease epidemic zone. Order of the Leye County People's Government [2020] No.1). [Cited 15 July 2020]. (also available at http://www.leye.gov.cn/tzgg/t5749164.shtml).

Liu, P., Li, J., Chen, R., Cheng, Z., Shi, Y., Baosuyalatu & Sun, X. 2020. The first outbreak investigation of lumpy skin disease in China. *China Animal Health Inspection*, 37(1); 1–5. (also available at http://zgdwjy.cahec.cn/zgdwjy/article/pdf/202001002).

Mercier, A., Arsevska, E., Cauchard, J., Caufour, P., Falala, S., Bronner, A., Bournez, L., *et al*. 2017. Modelling the spread of emerging infectious diseases in animal health: case study of lumpy skin disease in the Balkans, 2015–2016. In: New Zealand Veterinary Association eds. Proceedings of the 3rd International Conference on Animal Health Surveillance, 269–271. Rotorua, New Zealand, NZVA. (also available at http://agritrop.cirad.fr/586538/1/ICAHS%20proceedings%20%282017%29%20-%20Modelling%20the%20spread%20of%20emerging%20infectious%20diseas.pdf).

Ministry of the Foreign Affairs of the People's Republic of China. 2013. President Xi Jinping delivers important speech and proposes to build a silk road economic belt with Central Asian countries – 7 September 2013. Retrieved 15 September 2020. (also available at https://www.fmprc.gov.cn/mfa_eng/topics_665678/xjpfwzysiesgjtfhshzzfh_665686/t1076334.shtml).

Morgenstern, M. & Klement, E. 2020. The effect of vaccination with live attenuated Neethling lumpy skin disease vaccine on milk production and mortality—an analysis of 77 dairy farms in Israel. *Vaccines* Basel, 8(2): 324. (also available at https://doi.org/10.3390/vaccines8020324).

Muehlhoff, E., Bennett, A. & McMahon, D. 2013. Milk and dairy products in human nutrition. Rome, FAO. 376 pp. (also available at http://www.fao.org/3/i3396e/i3396e.pdf).

Muller, L. & Folly, G. 2018. Carcass management for small- and medium-scale livestock farms. In: FAO Focus on. (also available at http://www.fao.org/3/CA2073EN/ca2073en.pdf).

Myint, T., Sein Sein, M. & Khin Nyein, S. 2018. Recent developments in the cattle trade between Myanmar and China. In: Asia Beef Network [online]. Hanoi, Viet Nam [Cited 10 August 2020]. (also available at http://www.asiabeefnetwork.com/wp-content/uploads/2018/09/cattle-trade-report-myanmar-.pdf).

OECD/FAO. 2018. OECD-FAO *Agricultural Outlook 2018-2027*. OECD Publishing, Paris/FAO, Rome. 110 pp. (also available at https://doi.org/10.1787/agr_outlook-2018-en).

OIE – World Organisation for Animal Health. 2017. Lumpy skin disease. In OIE Technical Disease Cards. [online]. [Cited 12 August 2020]. (also available at https://www.oie.int/fileadmin/Home/eng/Animal_Health_in_the_World/docs/pdf/Disease_cards/LUMPY_SKIN_DISEASE_FINAL.pdf).

OIE. 2019a. Infection with lumpy skin disease virus. In: Terrestrial Animal Health Code (2019): Chapter 11.9, Paris, France. OIE. [Cited 20 September 2020]. (also available at www.oie.int/index.php?id=169&L=0&htmfile=chapitre_lsd.htm).

OIE. 2019b. In: Terrestrial Animal Health Code (2019). Chapter 4.18, Vaccination**.** Article 4.18.1. Paris, France. OIE. [Cited 20 September 2020]. (also available at: http://www.oie.int/index.php?id=169&L=0&htmfile=chapitre_vaccination.htm).

OIE. 2019c. Minimum requirements for the production and quality control of vaccines (Version adopted in May 2018). In: OIE. Manual of diagnostic tests and vaccines for terrestrial animals. 2019: Chapter 2.3.4, pp 287–297. Paris, France. OIE. (also available at www.oie.int/fileadmin/Home/eng/Health_standards/tahm/2.03.04_MANU_SITES_VACCINE_PROD_CONTROL.pdf).

OIE. 2020. World Animal Health Information Database (WAHIS) Interface. OIE, Paris. (also available at https://www.oie.int/wahis_2/public/wahid.php/Diseaseinformation/diseasehome).

Qureshi, M.A., Khan, P.A. & Uprit, S. 2016. Empowerment of rural women through agriculture and dairy sectors in India. *Econ. Aff.*, *61*(1): 75–79. (also available at https://doi.org/10.5958/0976-4666.2016.00011.5).

Ross, A. 2015. It's a small world. In: Southeast Asian Beef Market report [Online]. [Cited 12 August 2020]. (also available at http://seabeefreport.com/2015/03/17/its-a-small-world/).

Saegerman, C., Bertagnoli, S., Meyer, G., Ganière, J. P., Caufour, P., De Clercq, K., Jacquiet, P., *et al*. 2018. Risk of introduction of lumpy skin disease in France by the import of vectors in animal trucks. *PloS one*, *13*(6), e0198506. (also available at https://doi.org/10.1371/journal.pone.0198506).

Al-Salihi, K.A. & Hassan, I.Q. 2015. Lumpy skin disease in Iraq: study of the disease emergence. *Transbound. Emerg. Dis.*, 62(5): 457–462. (also available at https://doi.org/10.1111/tbed.12386).

SDC. 2015. Final report on the study of value chains for live animals/meat and hides/skins in Mongolia – 31 July 2015.

Si, Z., Guorong, Y., Waldron, S., Brown, C. & Smith, D. 2018. Developments in the China-Myanmar cattle trade. Asian cattle and beef trade working papers. 1. School of Agriculture & Food Sciences, University of Queensland. [Cited 12 August 2020]. (also available at https://espace.library.uq.edu.au/view/UQ:dee89bc).

Shidian County. 2020. 施甸县人民政府关于封锁牛结节性皮肤病疫区的通告. (Notice of the People's Government of Shidian County on blockade of lumpy skin disease epidemic zone). 17 August 2020. (also available at http://www.shidian.gov.cn/info/egovinfo/1001/xxgknry/01525934-9-/2020-0817003.htm).

Smith, P., Luthi, N.B., Huachun, L., Oo, K.N., Phonvisay, S., Sith, P., Abila, R., Widders, P., & Karan, K. & Miller, C. 2015. Movement pathways and market chains of large ruminants in the Greater Mekong Sub-region. (also available at https://rr-asia.oie.int/wp-content/uploads/2019/10/livestock_movement_pathways_and_markets_in_the_gms__final_.pdf).

Sohier, C., Haegeman, A., Mostin, L., De Leeuw, I., Van Campe, W., De Vleeschauwer, A., Tuppurainen, E.S.M., van den Berg, T., De Regge, N. & De Clercq, K. 2019. Experimental evidence of mechanical lumpy skin disease virus transmission by Stomoxys calcitrans biting flies and Haematopota spp. horseflies. *Sci. Rep.* 9, 20076 (2019). (also available at https://doi.org/10.1038/s41598-019-56605-6).

Spickler, A.R. & Roth, J.A. 2008. Lumpy skin disease. The Center for Food Security & Public Health – Technical Factsheets. (also available at http://www.cfsph.iastate.edu/Factsheets/pdfs/lumpy_skin_disease.pdf).

Staal, S., Ahuja, V., Hemme, T. & Sharma, V.P. 2016. Dairy economics and policy: focus on Asia. Dairy Asia Working Paper Series. Working Paper Number: 2016-02. (also available at http://www.dairyasia.org/file/Working_paper2.pdf).

Sudhakar, S.B., Mishra, N., Kalaiyarasu, S., Jhade, S.K., Hemadri, D., Sood, R., Bal, G.C., Nayak, M.K., Pradhan, S.K. & Singh, V.P. 2020. Lumpy skin disease (LSD) outbreaks in cattle in Odisha state, India in August 2019: Epidemiological features and molecular studies. *Transbound. Emerg. Dis.*, 00:1–15 [online]. [Cited 13 August 2020]. (also available at https://doi.org/10.1111/tbed.13579).

Tageldin, M.H., Wallace, D.B., Gerdes, G.H., Putterill, J.F., Greyling, R.R., Phosiwa, M.N., Busaidy, R.M.A. & Ismaaily, S.I.A. 2014. Lumpy skin disease of cattle: an emerging problem in the Sultanate of Oman. *Trop. Anim. Health Prod.*, 46(1): 241–246. (also available at https://doi.org/10.1007/s11250-013-0483-3).

Tianlin County. 2020. 田林县人民政府关于封锁牛结节性皮肤病疫区的命令. 田政令〔2020〕1号. (Order of the Tianlin County People's Government on the blockade of lumpy skin disease epidemic zone. TianOrder [2020] No.1). [Cited 20 July 2020]. (also available at http://www.tianlin.gov.cn/gdtt/t5753891.shtml).

Tuppurainen, E.S.M. 2017. Epidemiology of lumpy skin disease. *Empres360, 47*: 5–6. (also available at http://www.fao.org/3/a-i7982e.pdf).

Tuppurainen, E., Alexandrov, T. & Beltrán-Alcrudo, D. 2017. Lumpy skin disease field manual – A manual for veterinarians. FAO Animal Production and Health Manual No. 20. Rome. 60 pp. (also available at http://www.fao.org/documents/card/en/c/1fcf63b0-80e9-4f8e-825f-10ea6e998479/).

Tuppurainen, E.S.M., Babiuk, S. & Klement, E. 2018. *Lumpy skin disease.* Cham, Switzerland, Springer. (also available at https://doi.org/10.1007/978-3-319-92411-3).

United Nations Statistics Division. 2020. UN comtrade analytics [online]. New York. [Cited 5 August 2020]. (also available at https://comtrade.un.org/labs/data-explorer/).

Université Libre de Bruxelles and FAO. 2010. Gridded livestock of the world (GLW) [online]. (also available at https://dataverse.harvard.edu/dataverse/glw#:~:text=Aug%2023%2C%202018-,This%20dataverse%20contains%20peer%2Dreviewed%20spatial%20dataset%20on%20livestock%20distribution,%2C%20buffaloes%2C%20horses).

Wamwayi, H. 2004. The role of arthropod vectors in the transmission of lumpy skin disease in cattle. Applied Entomology, Kenyatta University. (PhD dissertation). (also available at https://ir-library.ku.ac.ke/bitstream/handle/123456789/14810/The%20role%20of%20arthropod%20vectors%20in%20the%20transmission%20of%20lumpy%20skin%20disease%20in%20cattle.pdf.txt;jsessionid=00D485DD5217C026A1E142F8F388B32A?sequence=3).

Weiss, K.E. 1968. Lumpy skin disease virus. In: Cytomegaloviruses. Rinderpest virus. Lumpy skin disease virus. pp 111-131. Virology Monographs. Wien, Springer-Verlag. (also available at https://doi.org/10.1007/978-3-662-39771-8_3).

World Bank. 2007. The challenges and potential of Pakistan-India trade. Washington, DC. (also available at http://documents1.worldbank.org/curated/en/990861468074627673/pdf/402730P07493901India1Trade01PUBLIC1.pdf).

World Bank. 2014. Islamic Republic of Afghanistan agricultural sector review - revitalizing agriculture for economic growth, job creation and food security. Washington, DC. (also available at http://documents1.worldbank.org/curated/en/245541467973233146/pdf/AUS9779-REVISED-WP-PUBLIC-Box391431B-Final-Afghanistan-ASR-web-October-31-2014.pdf).

Zhugunissov, K., Bulatov, Y., Orynbayev, M., Kutumbetov, L., Abduraimov, Y., Shaiyakhmetov, Y.,Taranov, D. *et al.* 2020. Goatpox virus (G20-LKV) vaccine strain elicits a protective response in cattle against lumpy skin disease at challenge with lumpy skin disease virulent field strain in a comparative study. *Vet. Microbiol.*, 245:108695. (also available at https://www.sciencedirect.com/science/article/pii/S0378113520300419).

Zia, M., Hansen, J., Hjort, K. & Valdes, C. 2019. Brazil once again becomes the world's largest beef exporter. In: Amber Wave, USDA Economic Research Service [online]. Washington, DC. [Cited 9 August 2020]. (also available at https://www.ers.usda.gov/amber-waves/2019/july/brazil-once-again-becomes-the-world-s-largest-beef-exporter/).

Annex 1

Compilation of major risk factors for LSD introduction and/or spread by country

COUNTRY|RISK FACTORS	Susceptible cattle and buffaloes	Bordering LSD affected country/ies	Formal importation of live C/B originating from LSD affected country/ies	(Semi)-informal importation of live C/B originating from LSD affected country/ies	Formal exportation of live C/B	(Semi)-Informal exportation of live C/B	Imports of any C/B products (e.g. meat, milk, or hides) originating from a LSD affected country/ies	Abundance of competent vectors for LSD transmission (+: very low; ++: low; +++: moderate)	Ongoing cattle/buffalo vaccination against LSD
Afghanistan	5 022 606	Yes	No	No	N/A	N/A	Yes	+	No
Bangladesh*	25 571 000	Yes	No	Yes	N/A	Yes	Yes	+++	No
Bhutan*	299 132	Yes	Yes	Yes	No	Yes	Yes	+	No
Brunei Darussalam	3 000	No	No	No	No	N/A	Yes	+++	No
Cambodia	3 507 298	No	No	No	No	Yes	No	+++	No
China*	90 536 564	Yes	Yes	Yes	Yes	N/A	Yes	+ to ++	Yes
Democratic People's Republic of Korea	570 231	Yes	No	No	No	No	No	+	No
India*	298 615 805	Yes	Yes	Yes	Yes	Yes	Yes	++ to +++	Yes
Indonesia	17 327 223	No	No	No	Yes	Yes	Yes	+++	No
Japan	3 842 000	No	No	No	No	No	Yes	+ to ++	No
Lao People's Democratic Republic	3 240 947	Yes	No	Yes	Yes	Yes	Yes	+++	No
Malaysia	870 254	No	No	No	Yes	Yes	Yes	+++	No
Mongolia	4 380 879	Yes	N/A	N/A	N/A	N/A	No	+	No
Myanmar	21 208 395	Yes	No	Yes	Yes	Yes	Yes	+++	No
Nepal*	12 654 125	Yes	No	Yes	Yes	Yes	Yes	+	No
Pakistan	84 932 000	Yes	No	Yes	N/A	Yes	Yes	+ to ++	No
Philippines	5 436 592	No	No	N/A	N/A	N/A	Yes	+++	No
Republic of Korea	3 520 886	No	No	No	No	No	No	+	No
Singapore	179	No	No	No	No	No	No	+++	No
Sri Lanka	1 419 530	No	No	No	No	No	Yes	+++	No
Thailand	5 914 926	No	Yes	Yes	Yes	Yes	Yes	+++	No
Timor Leste	334 864	No	No	No	No	Yes	No	+++	No
Viet Nam	8 228 012	Yes	No	Yes	No	Yes	Yes	+++	No

Annex 2

Parameters used to estimate the impact of LSD under different scenarios

We constructed scenarios using parameters extracted from the literature and/or outbreak reports from Middle East countries from 2012 to 2016 considering two scenarios regarding the spread of the disease.

	Cattle and buffalo population at risk	Reference
Scenario 1	3.42%	Median from official outbreak notifications from Middle East countries (5)
Scenario 2	10.52%	Mean from official outbreak notifications from Middle East countries (5)

We assumed that clinical signs appear on 18.5 percent of the cattle population at risk (1,2,5,6,13), but only 2.9 percent of the buffalo population at risk (4,11,12). For each scenario, two sub-scenarios were considered: medium impact and high impact. The parameters are summarized in the following table.

Parameter	Type	Medium	High	Source
Mortality rate	Exotic/crossbred	4.6%	8.1%	Medium: average from outbreak notifications (5) and the literature (1,2,6,13); high: average from the literature only (1,2,6,13)
	Indigenous	2.3%	4.0%	50% of mortality rate for exotic breeds
	Buffalo	0.0%	0.0%	Extracted from the literature (4,11,12)
Milk reduction	Exotic/crossbred	-52.0%	-83.0%	Medium: average from the literature (1,2,8,9,10); high: extracted from literature (10)
	Indigenous/ buffalo	-26.0%	-42.0%	50% of milk reduction for exotic breeds as suggested in literature (7,10)
	# of days	45	70	Extracted from the literature (7,10)
Weight loss (meat)	Exotic/crossbred	-6.2%	-23.1%	Medium: extracted from (7); High: extracted from (2)
	Indigenous	-1.2%	-1.2%	Extracted from (7)
	Buffalo	-1.2%	-1.2%	Same as indigenous breeds
Hide loss	*Hides from infected animals showing clinical signs are assumed to lose their commercial value*			Assumption due to the lack of data
Draught power loss	*22.5% of buffaloes are raised as source of draft power*			Extracted from (3)
	Same percentage assumed for cattle			Assumption due to the lack of data
	Cost associated with draught power loss			Extracted from (7)

ANNEX 3

Producers of lumpy skin disease vaccines

Type of vaccine	Virus strain	Producer
Attenuated LSDV vaccines		
Onderstepoort Biological Products Lumpy skin disease vaccine for cattle	LSDV Neethling strain	OBP, South Africa
MSD Animal Health Lumpyvax	LSDV Neethling strain	MSD, Animal Health, South Africa
BOVIVAX LSD	LSDV Neethling strain	MCI Santé Animale, Morocco
Herbivac LS	LSDV Neethling strain	Deltamune, South Africa
LSD-NDOLL	LSDV Neethling strain	Dollvet, Turkey
Lumpyvac™	LSDV Neethling strain	Vetal Animal Health Products S.A., Turkey
Attenuated SPPV vaccines		
Jovivac	Sheeppox virus strain RM-65	JOVAC, Jordan
Attenuated GTPV vaccine		
Caprivac Freeze dried live attenuated Goatpox Virus strain Gorgan vaccine.	Goatpox virus strain Gorgan	JOVAC, Jordan
Potential attenuated GTPV vaccine		
Goat Pox Vaccine*	Goatpox virus, live, Uttarkashi strain	Hester, India

* Goatpox virus Uttarkashi strain vaccine needs to be validated to confirm it provides the same protection against LSD as the LSDV vaccines.

REFERENCES FOR THE ANNEXES

Abutarbush, S.M. 2014. Efficacy of vaccination against lumpy skin disease in Jordanian cattle. *Vet. Rec.*, 175(12): 302–302. (also available at https://doi.org/10.1136/vr.102271).

Abutarbush, S.M., Ababneh, M.M., Zoubi, I.G.A., Sheyab, O.M.A., Zoubi, M.G.A., Alekish, M.O. & Gharabat, R.J.A. 2015. Lumpy skin disease in Jordan: disease emergence, clinical signs, complications and preliminary-associated economic losses. *Transbound Emerg. Dis.*, 62(5): 549–554. (also available at https://doi.org/10.1111/tbed.12177).

Cruz, L.C. 2007. Trends in buffalo production in Asia. *Italian Journal of Animal Science*, 6(sup2): 9-24. (also available at https://doi.org/10.4081/ijas.2007.s2.9).

Elhaig, M.M., Selim, A. & Mahmoud, M. 2017. Lumpy skin disease in cattle: frequency of occurrence in a dairy farm and a preliminary assessment of its possible impact on Egyptian buffaloes. *Onderstepoort J. Vet. Res.*, 84(1): e1– e6. (also available at http://dx.doi.org/10.4102/ojvr.v84i1.1393).

FAO. 2020. EMPRES-i Global Animal Disease Information System. LSD disease events reported by Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Saudi Arabia, Turkey, and the West Bank (2012-2016). In *FAO Animal Production and Health Division* [online]. Rome. [Cited August 2020]. (also available at http://empres-i.fao.org/eipws3g/).

FAO. 2017a. EMPRES360 Lumpy skin disease special issue. No. 47. Rome, FAO. (also available at www.fao.org/3/a-i7982e.pdf).

Gari, G., Bonnet, P., Roger, F. & Waret-Szkuta, A. 2011. Epidemiological aspects and financial impact of lumpy skin disease in Ethiopia. *Prev. Vet. Med.*, 102(4): 274-283. (also available at https://doi.org/10.1016/j.prevetmed.2011.07.003).

Hunter, P. & Wallace, D. 2001. Lumpy skin disease in southern Africa: a review of the disease and aspects of control. *J. S. Afr. Vet. Assoc.*, 72(2): 68-71. (also available at https://doi.org/10.4102/jsava.v72i2.619).

Karalliu, E., Boçi, R., Hatia, V., Prifti, V., Keçi, R., Manaj, B. & Koleci, X. 2017. A case study of lumpy skin disease outbreak in Rrapëz, Lushnje, Albania. *Albanian Journal of Agricultural Sciences*, 497-502.

Kiplagat, S.K., Kitala, P.M., Onono, J.O., Beard, P.M., & Lyons, N.A. 2020. Risk factors for outbreaks of lumpy skin disease and the economic impact in cattle farms of Nakuru County, Kenya. *Front Vet. Sci.,* 7: 259 [online]. [Cited August 2020]. (also available at https://doi.org/10.3389/fvets.2020.00259).

Mulatu, E. & Feyisa, A. 2018. Review: Lumpy skin disease. *J. Vet. Sci. Technol*, 9(535): 1-8. (also available at https://doi.org/10.4172/2157-7579.1000535).

Neamat-Allah, A.N. & Mahmoud, E.A. 2019. Assessing the possible causes of hemolytic anemia associated with lumpy skin disease naturally infected buffaloes. *Comp. Clin. Pathol.*, 28(3): 747-753. (also available at https://doi.org/10.3855/jidc.5038).

Tageldin, M.H., Wallace, D.B., Gerdes, G.H., Putterill, J.F., Greyling, R.R., Phosiwa, M.N., Busaidy, R.M.A. & Ismaaily, S.I.A. 2014. Lumpy skin disease of cattle: an emerging problem in the Sultanate of Oman. *Trop. Anim. Health Prod.*, 46(1): 241–246. (also available at https://doi.org/10.1007/s11250-013-0483-3).

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Lumpy skin disease (LSD) is a vector-borne disease of cattle and Asian water buffalo that is included on the OIE (World Organisation for Animal Health) list of notifiable diseases. In July 2019 LSD was introduced to Bangladesh, China, and India and then spread to Nepal and Bhutan and in 2020 to various provinces of China and India.

A qualitative risk assessment was conducted to assess the likelihood of introduction and/or spread of LSD in 23 countries in South, East and Southeast Asia based on information available up to 31 October 2020.

The economic impact of LSD for South, East and Southeast countries was estimated to be up to USD 1.45 billion in direct losses of livestock and production. These losses may be higher, due to the severe trade implications for infected countries.

This document provides an overview of LSD control approaches, including prevention. The cost-effectiveness estimation demonstrates a strong economic justification for vaccination and advocates for a regional approach to harmonize control measures.

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